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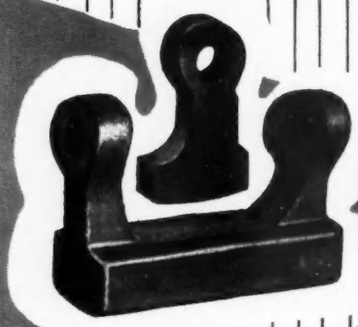

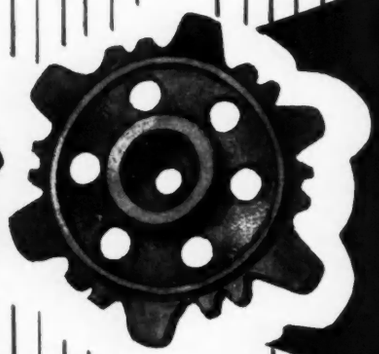

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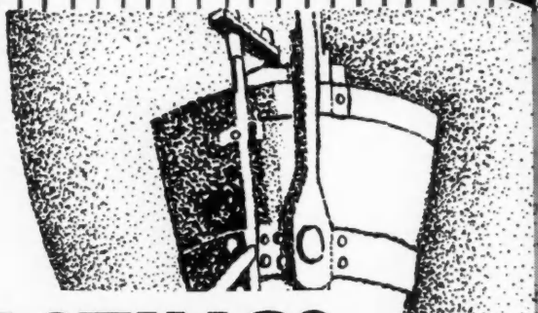

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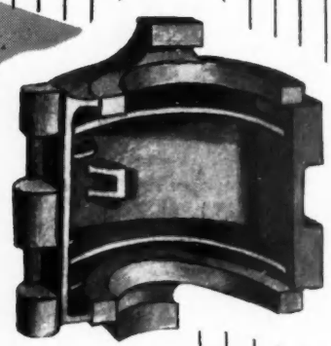

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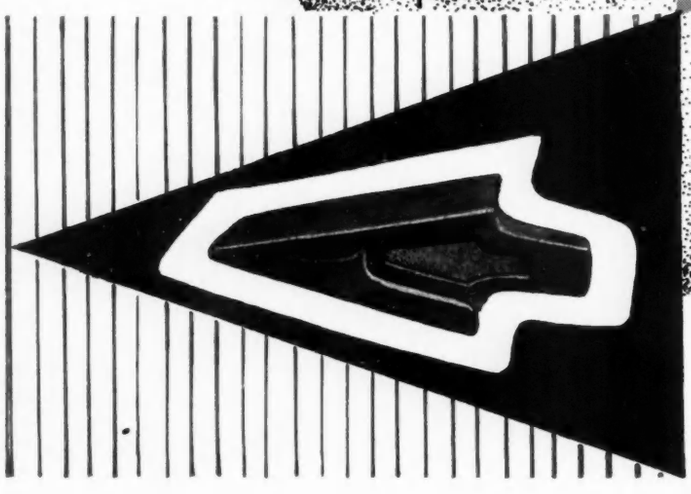

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Contents

193 **Leading Article**
Four Against Fred

194 **Plain Words**

195 **Letters to the Editor**
Motion of a Yacht
Ergonomics

198 **Special Article**
Tidal Model for Southampton Water

202 **Notices of Meetings**

204 **Atomic Review**
Concentrated Solution

207 **Companies in the News**

208 **In Parliament**

212 **Book Reviews**
Statistical Methods in Research and Production
Physico-Chemical Effects of Pressure
Jane's All the World's Aircraft, 1957-58

213 **New Books and Trade Publications**

213 **On the Shelf**

224 **Engineering at Home**
Sounds for Two Ears
Tools and Materials for D.I.Y.

. . . . . .

Management

194 Weekly Survey
210 Wages and Production
Prices and Good Management
Foremen into Managers
Management on a Large Scale

196 **Plant and Equipment**
Industrial Gas-Turbine: Blast-Furnace Gas or Oil Firing
Non-Inflammable Corrugated Roof Lighting
Gear Testing
Shaft Angle Coupling
Liquid Nitrogen Refrigerator

203 **The Human Element**

209 **Marketing**

211 **Metals and Materials**
Physical Properties of Gem Stones
Materials for Marine Superheaters
Glass-Fibre Sheet Development
Metallic Borides and Their Uses
Coal Blending and Coke Quality
Tungsten Electrodes for Argon Arc Process
Cement for Setting Paint Brushes
Steel in Agriculture

214 **Research and Development**
High-Speed Photography: A Tool for the Engineer
Research on an International Theme

218 **Production**
A Steelworks Goes in for Mobile Plant: Scrapers, Shovels, Excavators at Steel Company of Wales
Air Gauging Applications

222 **Construction**
Refinery Gases Used in Homes: Shellhaven Supplies Romford

Four Against Fred

WHENEVER resources of manpower and equipment have to be mobilised quickly there is a certain amount of confusion. Basic objectives become blurred by the need to think up intelligent short cuts. There is conflicting advice from groups of well-intentioned people who are allowed—or are able—to see only a part of the problem. Vested interests and petty empire builders exert such pressure as they can in their own interests and gang up with one another to achieve common, if temporary, ends.

The outstanding example of this problem is the mobilisation of manpower in war-time but the same difficulties now afflict the mobilisation of adolescent manpower for technical training. There is an existing framework of technical education, a certain amount of money, a mass of traditional method and prejudice, unlimited professional and amateur advice and, above all, immense urgency. Yet unless the objectives and the main problems to be tackled are kept constantly in view the whole exercise will dissolve in chaos and waste.

What are the main objectives to be achieved? We know that in this country the amount of manpower receiving technical education at all levels is inadequate for our prospective needs in the second half of the Twentieth Century. We need more and better technical people at every level of knowledge and responsibility. This is the first fundamental to be emphasised.

We most certainly do not want a large number of people of average ability forced through advanced courses for which they are unsuited. This basic point needs far more attention than it is getting. It involves accepting the idea that first-rate men of the highest qualifications should be trained to delegate certain technical responsibilities to other grades of technical skill and that the industrial environment shall exist to make this possible in practice. It involves putting the utmost pressure on craft unions, technical colleges and employers to revise radically the apprenticeship system so that skilled workers can be more quickly trained.

A second fundamental is the need to achieve the right kind of co-operation between educationalists and industrialists. It is vitally important to keep technical education moving in parallel with industry. If this is not done men will have the wrong kind of special training because the colleges are not fully aware of the development needs of industry. There is need for compromise and give and take on this issue. Already influential people on each side of the argument are not seeing eye to eye. In the 1957 Viscount Nuffield Paper, " Technical Education for Production Engineers—Some Reminiscences and Experiences," Lord Hives had the following remark to make, among others, about the National Council for Technological Awards of which he is chairman. " The work of the Council in setting a high and independent standard is bearing fruit in encouraging improvement. The Dip.Tech. scheme under the charge of an independent body, means complete freedom from traditional methods." On the other hand Dr. P. F. R. Venables, the Principal of the College of Technology at Birmingham, recently said in an article in *Research:* " At present, the whole relationship with the Hives Council would appear to be permanent; if so, the colleges of advanced technology will be in permanent academic dependence upon the approval of a body which is in no significant way representative of them." Here is the understandable difference between the industrialist and the educationalist. Dr. Venables goes on in his article to emphasise the importance of getting the right educational structure and of making salaries and prestige at advanced technical training centres comparable with those of university appointments.

The third fundamental from a strategic point of view is to produce the structure of technical education which is to some extent flexible—to meet the demands of industry which in itself is in a perpetual, if healthy, state of flux. This involves mobilising the necessary teachers, equipment and buildings in the right places to give the correct degree of specialisation. It is a critical and intricate exercise for it has to be carried out in craft training as well as in higher technological studies. It pre-supposes an understanding of the proportions in which the degrees of technical knowledge from craftsmanship to post-graduate research shall be mixed. The fourth fundamental is to adjust the broad education of the young to fit the technical education of the adolescent.

If these basic objectives are lost sight of in a plethora of tactical battles at various points over the whole field of technical education the result will be chaos. To return to the military analogy, there will be artillery without guns, infantrymen with pikes, and sappers with stethoscopes. Such an army will be big; it may even be impressive, if the men are added up on one page and the equipment is added up independently on another. But like Fred Karno's army—it will neither march nor fight.

Cover Picture. *Rolled products, after inspection, are identified by tags and other means, and usually the ends of various batches are painted in contrasting colours. The illustration shows bundles of flat and round bars being weighed prior to dispatch.*

* * *

Plain Words

No one knowingly runs his business on superstition, but I sometimes wonder how many of our decisions are based unconsciously on irrational assumptions. We may no longer study the flight of birds or peer into the entrails of decomposing rodents to help us plan campaigns, but omens and auguries of a more modern kind are not excluded from our judgments. Some of our superstitions we have inherited, though possibly in a transmuted form; others we have created for ourselves.

Captain Marryat in *Peter Simple* tells of a certain midshipman, who, asked how he had escaped being killed, answered that " he always made it a rule, upon the first cannon-ball coming through the ship's side, to put his head into the hole which it had made; as by a calculation made by Professor Innman, the odds were 32,647 and some decimals to boot, that another ball would not come in at the same hole."

The belief that cannon-balls do not fall in the same place twice may reappear in new disguises: in the planning of production or maintenance, for example, or in the forecasting of sales. Heaven help the factory where the maintenance routine is organised on the assumption that a machine which breaks down once will not break down again.

A faith in science unaccompanied by a knowledge of its methods is a rich source of modern myths. A so-called law of averages is often quoted to support an optimistic forecast that bad lack is about to change. If a coin is tossed five times, and each time it turns up heads, is it more likely to turn up tails at the next toss? Can one result be affected by those that went before? In the face of experience and the arguments of mathematicians, many still base judgments on this supposition. One might almost as well argue that a slackness in sales of paraffin lamps over recent years portends an imminent revival in demand.

Curiously enough, common-sense is nowadays often an ally of superstition. Basing our decisions on what we term experience, we frequently give unconscious but substantial weight to what in fact is merely prejudice. Even a man with fifty years experience cannot tell hot from cold, light from heavy, or sweet from dry with any accuracy unless he uses instruments; how can he hope to judge a market, an organisation, or another man? Systematic methods have been devised to help him but still he would in many cases rather trust himself. The trouble is that he is often right—and nothing more confirms a man in error than being right. Common-sense has a very questionable record in the history of science. Like superstition, it was once a useful guide; but now we have more serviceable tools.

CAPRICORN

Weekly Survey

Changing Trends in Fuel Consumption

When he announced the establishment of a committee to consider ways of improving co-operation between the Electricity and Area Gas Boards, the Minister of Power last week drew attention to the change in the pattern of fuel consumption since the war. He said that since 1948, while the consumption of coal had increased by only 10 per cent. and of coke by 15 per cent., that of gas had risen by 27 per cent., of oil by 91 per cent. and of electricity by 99 per cent. Whereas before the war gas and electricity had accounted for a quarter of the total fuel consumption, they now accounted for over 40 per cent.

Lord Mills said that while a turning point had been reached with the advent of nuclear power, he had no doubt that coal would remain the basis of the fuel economy for many years to come. Nevertheless, with rising stocks of small coal, and the fall in oil prices, it may no longer be necessary to insist on maximum production of coal regardless of cost and it is reported that the National Coal Board are beginning to consider ways of curtailing marginal production.

On the short view, current consumption of coal is running about 3 per cent. below that of last year. Nevertheless, the problem of limiting high cost production is by no means simple, since it has been estimated that out of approximately 10 to 12 million tons produced annually, from sub-marginal pits, about 60 per cent. consists of anthracite, house coals and other grades which are in heavy demand, while the existing heavy stocks comprise mainly small coal.

Before formulating any major change in fuel policy, however, it must be remembered that the present situation follows two years of virtual industrial stagnation. A resumption of rapid expansion of industrial output might quickly change the general outlook. A very important factor contributing to the present unbalance of the supply and demand of different grades of coal is undoubtedly the fact that the differential between prices of large and small coals is insufficient and it is expected that a new price structure involving greater differentials will be announced later this year.

The Importance of H.P.

The credit squeeze has had no perceptible effect on hire purchase. Figures recently released by the Board of Trade show that hire purchase debt outstanding is now at least £413 million, following a steady rise throughout 1957. Nor have the hire purchase companies found it difficult to maintain an adequate stream of finance for their customers. It has been made more difficult for them to obtain credit from the commercial banks, but most of them have found that, by raising the interest rates on deposits made by private investors (itself a growing facility that bears watching) they have been able to attract enough funds to increase their business. Sir Arthur Morse, C.B.E., the chairman of Bowmakers Limited, one of the largest hire purchase companies in this country, said in his annual report published recently that 1957 had witnessed the " highest volume of business transacted and the biggest profit in the history of the company." Deposits made with Bowmakers have also risen substantially, particularly in the last six months of 1957, after the company raised its interest rates.

To the extent that hire purchase companies attract deposits, hire purchase may be said in a limited sense not to be inflationary since it attracts small savings, although this argument assumes that the savings would not otherwise have been made. A booklet published by the Institute of Economic Affairs last week entitled " Hire Purchase in a Free Society " maintains that in most respects hire purchase is in fact a symptom, and not a cause, of inflation, since, it is argued, people have become wary of saving money with the continuous fall in its value and have " invested " in goods instead.

Whether hire purchase is inflationary or not is very much open to question. Certainly it has helped to boost sales of engineering products in the face of the credit squeeze. Hire purchase has been of particular value to manufacturers of motor vehicles. Of the new hire purchase credit extended by finance companies direct to hirers, over 30 per cent. goes towards financing purchases of new cars and commercial vehicles. In June, 1957, for example, out of a total of £23·7 million of direct hire purchase lending, £7·9 million went to prospective purchasers of vehicles. This figure represents about 15 per cent. of total vehicles sales. All but a small proportion of hire purchase finance is in fact lent to buyers of engineering products, notably of motor vehicles and motor cycles, but also of farm and industrial equipment and, of course, a wide range of domestic appliances, radios and television sets.

Productivity and Prices

The January issue of the Treasury *Bulletin for Industry* makes some sound comments on industrial efficiency. Price stability requires a favourable economic climate, which the Government's restrictive measures of September are intended to produce, restraint in wage claims and profit margins, and the keeping down of costs by improving efficiency. On this third requirement productive industry, both public and private, has the most scope.

Between 1952 and 1956 the average price of manufactured goods rose less than prices generally, although material costs increased faster for manufacturing than for the economy as a whole. It is therefore fair to deduce, states the *Bulletin*, that labour costs per unit of output must have risen less in manufacturing. One reason for the increase in productivity is that the investment boom of the past three years has been heaviest in manufacturing industry. In 1956 the total of fixed investment was 21 per cent. higher than in 1953 but in manufacturing industry it was up 37 per cent.

Where has new investment in manufacturing industry been applied? Compared with 1953 investment in shipbuilding, engineering and vehicles was 100 per cent. up, iron and steel was 67 per cent. up, food, drink and tobacco 56 per cent., chemicals 40 per cent. and textiles and clothing 25 per cent. In this list, apart from shipbuilding, the biggest advances have been in growing industries. The trend of productivity, however, has been disappointing. In 1953 and 1954 output per man rose by 5½ per cent., and in 1955 by 4 per cent. Then in 1956 it fell by 2 per cent. Last year it recovered to increase 3 per cent. in the first nine months. The good effect of new investment on efficiency and costs has in fact not yet been felt.

If firms had used their improved equipment to the full, says the *Bulletin*, the same output could have been achieved with fewer men, and output per man would have risen. But on the whole workpeople have been kept on for a mixture of social and economic reasons, and in expectation of an early revival in demand. As a result the output per man in manufacturing industry has not increased. Labour costs per unit have risen as the total of wages and salaries in manufacturing has tended to outpace productivity.

By December, the prices of imported raw materials were on average 10 per cent. lower than in April last year. Falling raw material

costs and the unrealised prospects of increased productivity give scope for a fall in prices of manufactures. Such a fall, concludes the *Bulletin*, is a condition of stable prices generally.

High Authority Gets Tough

The High Authority of the European Coal and Steel Community had considerable powers conferred on it by the Treaty signed by the 6 member countries in 1950. These are intended to enable it to maintain the common markets for coal, steel, iron ore and scrap, prevent the growth of cartels and generally to promote higher standards of production and social welfare. The High Authority has started the year with three separate demonstrations of its determination to enforce the Treaty. An Italian steel firm has been fined ten million lire (£5,800) for failing to publish its price lists, not paying the Community levy on production (from which the High Authority derives its income), and not paying the scrap import compensation levy. The fact that the High Authority comes down heavily on offenders is one reason why such cases are so rare.

The other two matters concern German coal. The Federal Government is proposing to exempt from turnover tax coal imported into Germany. The High Authority considers that this exemption would represent a discrimination against German coal producers. Discussion on this question is still going on. The third objection is of rather longer standing. The High Authority objected to what it regarded as a subsidy to German coal producers through the Federal Government paying part of the social insurance contributions. Since December, 1956, the Federal Government has borne part of the coal industry's social insurance contributions as a means of stabilising wages. This practice has been in dispute and the Federal Government has agreed to bring it to an end on March 31 next.

Dr. Erhard attended a meeting of the High Authority on January 22 at which the three Ruhr coal selling agencies said that they will do all they can to avoid any further rise in coal prices for some time to come. The Government's social service payment amounting to 6½ per cent. of the basic wage so that something like 3*s*. 4*d*. a ton will be added to the producer's costs. The selling agencies will do very well if prices remain stable in the second quarter of the year.

European Industrial Conference

The economic and social problems connected with the Free Trade Area are to be discussed later this month at a conference in London. The United Kingdom Council of the European Movement has arranged it as something of a culmination to a series of regional meetings which have been organised by this Movement in the provinces under the auspices of the Board of Trade.

Four main commissions are to meet after the opening speeches. These will deal with problems arising from the removal of tariffs and quotas, social policies, co-ordination of economic and monetary policy and food and agricultural problems. All four are of vital concern in the structure of a Free Trade Area as now being negotiated but the third one, bringing in monetary policy may produce the most original ideas. The currency and international clearing aspect of an F.T.A. have received little attention so far in public discussion. The conference is exploratory and no resolutions will be tabled.

It is expected that the Continental delegation will be a strong one. The United Kingdom delegation promises well, with the engineering industry well represented both on the management and the trade union side. The conference will be opened by the Chancellor of the Exchequer, and Mr. Robert Schumann, President of the European Movement, will be there as well. Conferences of this kind have an important function to perform at the present time. They provide a forum for intelligent, constructive discussion at a time when the negotiations are in hand and when pressure groups are active. This one will help to keep an informed public discussion alive while the bargaining goes on at the diplomatic level. It may also help to show our Continental colleagues the real earnestness of the British attitude to the Free Trade Area.

A.S.M.E.

The annual report of the American Society of Mechanical Engineers for the fiscal year October 1, 1956, to September 30, 1957, shows that at the latter date the Society comprised over 44,000 members and 10,000 students. Probably best known in this country for its work on codes and standards, the activities of the Society also cover the organisation and administration of programmes of research, the improvement of engineering education, the promotion of meetings for the discussion of new advances in engineering and the publication of four periodicals and over 800 technical papers each year. The importance of this latter function is shown by the fact that of a total income of 2·4 million dols. in 1956/57, receipts from publications accounted for 1·6 million dols. against subscriptions from members and students amounting to 0·7 million dols.

Research projects administered by the Society include investigations of the thermodynamic properties of steam, at Brown University, California Institute of Technology and Georgia Institute of Technology, as part of an international project which aims to secure information for new steam tables extending to 15,000 lb. per sq. in. and 1,500 deg. F. Other work is in hand on high temperature steam generation and on the effects of extreme temperatures, both high and low, on the behaviour and properties of metal.

Hot Under the White Collar

One of the changes made by Dr. Adenauer in the reshuffle following the German elections was to abolish the post of Minister for Special Tasks and give his duties to Herr Blank, the Minister for Labour and Social Affairs. This change is of particular interest as the "Special Task" of the vanished minister was to look after the interests of the middle classes. To-day some 4 million people are estimated to be in this category. Although salaries of Germany's white collar workers have risen, they have done so more slowly than those of industrial workers. In the chemical industry while salaries are now about 75 to 80 per cent. above 1938 levels, wages of the factory workers have shot up by 145 per cent. This loss of differential is felt all the more keenly by the salaried staffs because the fringe benefits which used to be their prerogative have now been passed on to the workers. Old age pensions and disability allowances are now at about the same level for men in the office and the factory. The workers also enjoy the same paid holidays and length of sick pay as the salaried employees.

D.A.G., the white collar workers union, takes the view that while there is no objection to the workers' standards going up, the efforts of their own members is being grossly undervalued. D.A.G. proposes better salaries and reforms to ease the burden of income tax on their members. At the same time salaried workers are apprehensive about the appearance of automation in the offices and they are pressing for safeguards against unemployment and compensation for redundancy. Roughly 2 per cent. of white collar workers are now without jobs. The salaried worker in Germany is in no worse plight in material terms than his opposite number here. But in a land where status is more important than income, he feels very strongly that he has lost face and security.

Letters to the Editor

MOTION OF A YACHT

SIR, Loth though I am to engage so eminent an engineer and yachtsman as Mr. H. Dick Broom, his letter published in your issue of January 24 (page 99) tempts me to try to demolish some of his criticisms of Mr. W. A. Crago's article "The Motion of a Yacht Through Air and Water."

This subject of yacht behaviour, being as yet one which has hardly been studied with any degree of method in this country, is a subject upon which a vast number of muddled, pseudo-technical and highly-dogmatic statements have from time to time been made, notably in the columns of a section of the yachting Press. One recalls a diverting, if over-long, correspondence in such a paper, purporting to discuss the way in which a vessel sails to windward—and a rational approach to the matter, such as that made by Mr. Crago, is to be welcomed by all thinking yachtsmen, and not to be subjected to niggling criticism.

Surely, "round bilge" and "hard chine" need no explanation to people interested enough to read as far as Fig. 7? Surely, the convention of exaggerating small angles in diagrams, such as Figs. 4 and 6, for the sake of clarity is well enough known? Surely, Mr. Broom has mistaken apparent wind and angle of attack when he criticises Fig. 3? And surely a catamaran cannot develop her full righting moment until the weather hull emerges? (Although I agree that the one in Fig. 8 is overdoing it somewhat—perhaps she is absorbing some gust energy, while the weather rudder is clearly being used to obtain aerodynamic stability.)

And why *not* mention Sceptre and a plywood dinghy in a suitable context in the same article? Do they not float in the same medium? Can they not be made with the same materials?

No, H.D.B., it will not do
Swanhildian silver rings not true.

Yours faithfully,

MICHAEL HENDERSON.

Cowes, I.O.W.
February 2, 1958.

[*Editor's Note*: A further letter on this subject appeared in our issue of January 17, page 68. Mr. Crago's article was published on page 6 of our issue of January 3.

ERGONOMICS

SIR, Thank you very much indeed for your comments about *Ergonomics* in your "On the Shelf" note on page 57 of the January 10 issue of ENGINEERING. We are glad to have a kindly and appreciative note, and the fact that it was so makes me feel badly about voicing a small complaint. It is about the last sentence: ". . . The accent, by the way, is on medicine and not operational research." We are really interested in problems of the design of equipment and work layout, bearing in mind the potentialities and limitations of the human beings who are to use them.

This does, of course, involve the application of fundamental principles from the human biological disciplines, especially anatomy, physiology and experimental psychology. It is fair to say, however, that ergonomics has grown directly from these disciplines because of their application to problems of equipment design during the war, and is not primarily medical in orientation. The Ergonomics Research Society and the journal are intended to bring those working in the human biological disciplines into touch with engineers, industrial medical officers and industrial management, and we hope to cover a field bordered on various sides by design engineering, industrial medicine, work-study, and the mathematical techniques which have come to be known as operational research.

Yours sincerely,

A. T. WELFORD,
Editor, *Ergonomics*.

The Psychological Laboratory, Cambridge.
February 5, 1958.

Plant and Equipment

INDUSTRIAL GAS-TURBINE

Blast-Furnace Gas or Oil Firing

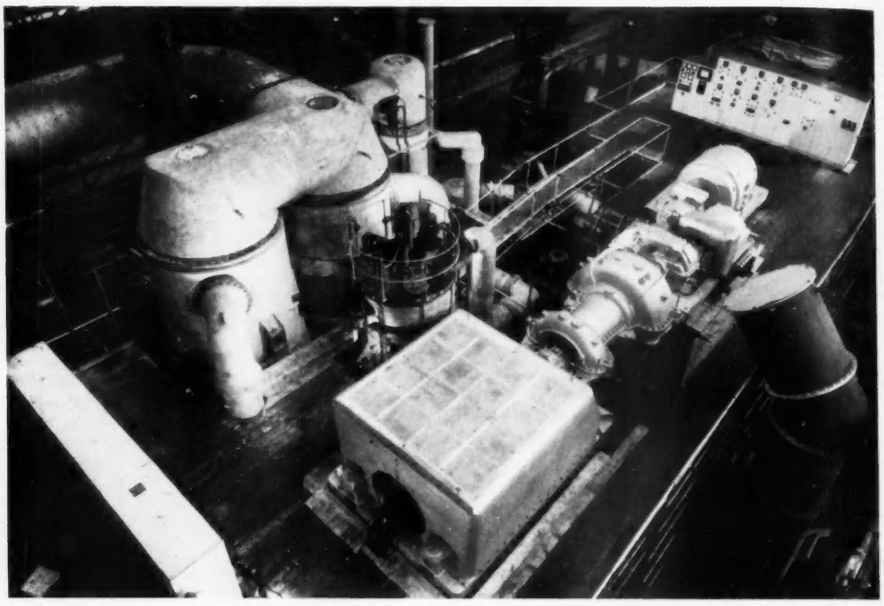
The gas-turbine alternator set that has just been completed by Richardsons Westgarth (Hartlepool) Limited at West Hartlepool is the first of its kind to be used in this country in a steelworks. It has been built to Brown Boveri designs and will be installed at the works of Shelton Iron, Steel & Coal Co. Ltd., in the next few months. Designed for an output of 2,500 kW under ambient conditions of 60 deg. F. and 14·7 lb. per sq. in., the unit will run on blast-furnace gas. Trials at the works, however, have been conducted on oil fuel and the power has been easily obtained without exceeding the design turbine inlet temperature of 650 deg. C. As the alternator and gearing are rated for 3,200 kW it is expected that the unit will be able to give more power than has been specified. The guaranteed overall efficiency is 20·5 per cent.

The unit is of the open cycle type with regenerators, and has an additional blower for compressing the blast furnace gas, also fitted with a heat exchanger. The 14 stage axial flow air compressor has a ratio of 4 to 1 and runs at the turbine speed of 5,350 r.p.m. The gearbox steps down the turbine speed to 3,000 r.p.m. for the alternator, and up to 7,970 r.p.m. for the gas compressor. The slip-ring starting motor, rated at 142 kW, is mounted on the same shaft as the alternator and has automatic gear to lift the brushes clear of the rings when the turbine has reached speed. It also has automatic accelerating relays to bring it up to 1,000 r.p.m. Both turbine and compressor run in force-lubricated white metal bearings.

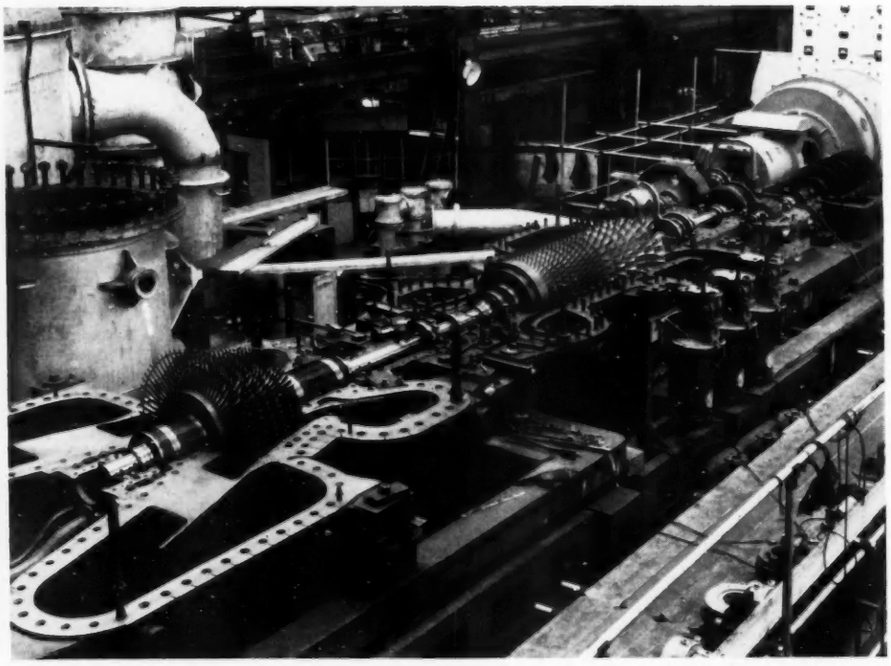
The casings of both the turbine and compressor are split in the horizontal plane along the centre-line of the shaft. Sealing is by labyrinth glands. In addition, there is a split in the vertical plane in the turbine casing approximately in line with the last stage of blading (it is a six stage reaction type) enabling the inlet and cylinder section to be made of an alloy ferritic steel casting and the exhaust section to be partly cast and partly fabricated from molybdenum steel plates. The inlet branch contains a lining of chromium steel plate, behind which cooling air (bled from the combustion chamber) circulates, eventually spilling over the first row of cylinder blades and so assisting in cooling them.

The combustion chamber is vertical and all-metallic with a pressure-tight outer casing and an inner lining, the upper part of which consists of three concentric rings, the largest being at the bottom. These three rings carry metal tiles made up of heat-resisting steel plates welded together to form a series of fins. The smooth face of weld metal is exposed to the flame and air circulates behind and between the fins, cooling the tiles. As the latter are only hung in place by hooks they are very easily and cheaply replaced if need be.

As the plant is intended to be run on either furnace gas or oil, or on a mixture of both if gas is in short supply, two burners are provided. A magnet valve on top of the chamber controls the servo motor which introduces the oil burner under the overriding control of the relay oil system. Ignition is by a glow-type ignition rod. The two main heat exchangers are arranged in parallel and have hand-operated soot blowing apparatus in their bases. Air for this is supplied from the main compressor.



Shown at the maker's works, the 2·5 MW turbo-alternator is designed for running on blast-furnace gas, gas oil or a mixture of both. On the left are the heat exchangers and the vertical combustion chamber; on the right is a temporary air intake pipe.



The gearing is standard Brown Boveri design consisting of single helical gears with a thrust collar on the pinion to prevent any thrust being transmitted to the adjoining units. This particular box was made in Switzerland. The alternator is also a standard machine, generating at 5,500 volts.

Owing to the comparatively small size of the unit the gas compressor is of the centrifugal flow type as against the more usual axial flow models employed on similar sets on the Continent. It has six stages and is designed for a slightly higher compression than the main compressor. It has " fixed-adjustable " diffusers which can be set to give the required performance per stage and then locked in position. When the unit is to be run on oil for a considerable time the gas compressor is set to supply air to the combustion chamber. To avoid condensation of the moisture which is always present in blast-furnace gas, the inlet temperature is kept at 30 deg. C.

The regulating system for the whole plant is hydraulic and almost completely automatic. Starting is by a 12 position sequence controller, the various relays deriving their supply from an auxiliary oil pump in parallel with the main pump. The sequence controller also operates the shut-down procedure, which includes switching on the relay that controls the barring gear. This works with a ratchet mechanism that turns the shaft through 180 deg. every half hour (on the standard setting) but the timing can be set as required. In the event of a supply failure, the ratchet can be operated by hand, and a battery-driven motor has been fitted to supply the bearing oil.

In the governing system there are protective relays to shut down the plant in the event of failure of any part. A pulsator ensures that there is no risk of the relays sticking.

NON-INFLAMMABLE CORRUGATED ROOF LIGHTING

Roof lighting has been extensively used throughout industry and for many years this has taken the form of patent glazing, which requires the use of long continuous runs of flat glass. This tends to result in uneven light distribution as it produces a high concentration of light in the centre of factory floors, which becomes sharply reduced towards the corners of the building. To illuminate the dark areas, and to avoid possible danger to the safety of workpeople, artificial lighting is necessary. Thus much of an anticipated saving is lost. In addition, this form of roof lighting requires constant maintenance; rain channels have to be kept clear and glazing bars and sealing components, being exposed to atmosphere, need continuous attention.

A partial solution to the problem was found with the introduction of synthetic corrugated roof-lighting materials, which diffuse light over a wider area. These are, however, highly combustible. Over a six-year period the average loss from fire, in this country, amounts to nearly £7,300,000 per annum and the danger of fire spread, particularly in roofs, is a matter of considerable concern to industrialists, architects, municipal surveyors, insurance companies, fire services and safety officers. The use of synthetic materials in buildings which have to conform to a high degree of fire resistance is, as a result, the subject of bye-laws by most local authorities. In fact, many have prohibited the use of synthetic roof lighting sheets except under stringent regulations.

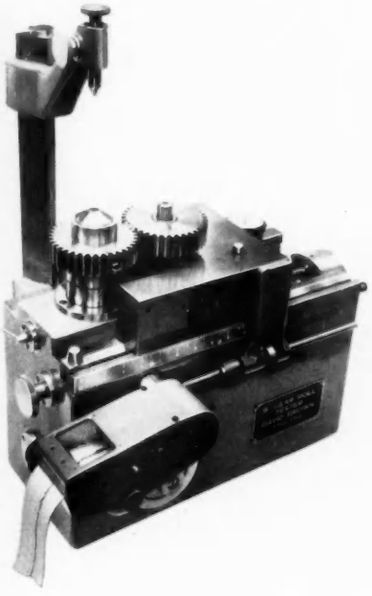
Material	Time lapse before ignition	Spread of flame after 30 secs.	Condition after 3-3½ minutes
Sample "A"	5-7 seconds	2 in.	Complete disintegration with molten material dripping off.
Sample "B"	5-7 seconds	2 in.	Completely burnt out —only shell of burnt out fibre remained.
Corroglaze	No ignition	No ignition	No melting, the only effect being a slight cracking of the glass.

A solution to the problem is claimed by Corroglaze, Limited, Wembley, Middlesex. They supply Corroglaze—an annealed wired glass which forms a non-combustible, corrugated, roofing material.

Tests, to B.S. 476: 1953, by an independent laboratory have been carried out on three of the various forms of roof-lighting materials now available and the results are summarised in the adjacent table.

Corroglaze has other advantages. The company claim that the prismatic ribbing on the underside of the sheets so spreads the light that a virtually shadow-free and uniform distribution of light is achieved. The glass can be fixed by the contractor responsible for roof cladding and is available ready mitred, if required, in a wide range of sizes. A 6 in. nominal profile to suit Big Six and Standard Six Asbestos cement sheets is available. In addition, a 3 in. profile meshes with 10/3 in. corrugated iron, aluminium or Cellactite sheeting in general use.

GEAR TESTING



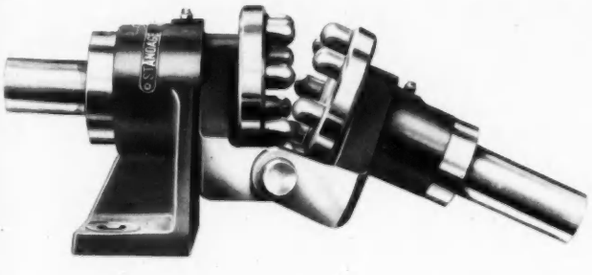
An instrument for testing and recording concentricity, tooth contact, centre distance and tooth thickness of gear wheels has been developed by the David Brown Companies Limited, Meltham, Huddersfield, Yorkshire. It is shown in the illustration on the left.

The standard instrument will accommodate spur or helical gears up to 9 in. centres. Attachments are available for shaft gears, bevel gears and worm gears. Errors are recorded on a dial indicator, graduated to 0·0005 in., which is in contact with a sensitive carriage loaded by adjustable springs. Actual gear centre distances are read directly from the vernier scale at the front of the instrument. The graphical recorder, which is driven from the same motor that revolves the gear, has an actual range of 0·008 in. and gives a magnification of 250 to 1. An actual error of 0·0002 in. is therefore shown as 0·05 on the graph paper. The drive is arranged so that one revolution of the gear under test produces a recording 12 in. long.

Concentricity, tooth contact, centre distance and tooth thickness of gear wheels can be measured on this David Brown instrument, and at the same time a graphical record is made.

SHAFT ANGLE COUPLING

In the remote manual control of apparatus by mechanical means it is almost inevitable that there must be some form of angle joint in the connecting link. In some cases this is met by the use of a flexible cable, but such an arrangement is not always desirable. In others a flexible coupling is employed. For use when the link between the control position and the apparatus is made with steel rods, the Lineta Uni-Joint has been introduced by Standage Power Couplings Limited, Telscombe Cliffs, Newhaven, Sussex. One is shown in the illustration below.



The Lineta Uni-Joint affords an angular drive between two shafts with provision for altering the relative angle form 0 to 90 deg.

As may be seen it consists of two face plates with a series of projecting studs which mesh with each other. One of the driving axles is carried in a fixed bracket and the other in a bearing joined to the first by a trunnion. The pivot of the trunnion allows the shafts to be at any angle up to 90 deg. to each other, and the trunnion can revolve around the fixed bracket through a full circle. The shape of the studs is such that they continue to mesh at any position within this range.

Five sizes are made for shafts ranging from ½ in. to 1½ in. in diameter. The fixing can be either by bracket as in the illustration, or by a flange when the axis of the shaft is perpendicular to the surface (as when it passes through a wall). For all sizes the joint will transmit as much torque as the shaft and there is a constant velocity ratio between the shafts.

LIQUID NITROGEN REFRIGERATOR

Liquid nitrogen is now frequently used for the cooling of various items, particularly in medical and pharmaceutical research, chemical laboratories and food processing, and a portable unit has now been produced by the Linde Department of the Union Carbide International Company,

One charge of liquid nitrogen will last for 34 days in this portable refrigerator.

30 East 42nd-street, New York 17, N.Y., U.S.A. The new container has been both laboratory and field tested, and has proved successful.

A double-walled jacket of Heliarc welded stainless steel is insulated by the combination of a powder under vacuum. The centre container is filled with liquid nitrogen and the accessory storage baskets for holding the material for freezing or for cold storage, are lowered into the liquid. A single charge of nitrogen will last 34 days. The unit weighs 115 lb. when fully charged and can be handled comparatively easily. Empty, the weight is only 60 lb.

XUM

Special Article

TIDAL MODEL FOR SOUTHAMPTON WATER

When the "Queen Elizabeth" and "Queen Mary" come up Southampton Water to the Ocean Terminal they do so, at some points, with only small clearances, sometimes as little as 3 ft., below the keel. At present, tankers of 50,000 deadweight tons berth at the oil jetties in the lower reaches of the estuary and 80,000 DWT tankers could do so at ideal high water conditions. For larger vessels, such as 100,000 ton super-tankers, however, a deeper dredged approach is required in the eastern arm of the Solent; there is good reason to believe that this is a practicable and economic proposition and that such vessels will be able to enter and berth safely at future oil jetties inside Calshot. But the safe navigation of such large ships both now, and for the future, is a subject for very close scrutiny.

Fortunately, the bed of the estuary is fairly stable and although dredging is necessary there is not a constant fight against shifting banks. Nevertheless, the construction of new works—in particular, a new jetty and with its own deep approach channel— might well set up undesirable currents which could alter the navigable channel in such a way as to restrict the movement of shipping. A proposal, therefore, of Caltex Services Limited to construct near the mouth of the River Hamble a new oil jetty to receive 50,000 ton tankers (and possibly super-tankers at a later date) caused some concern to the Harbour Board. Before the Board were willing to sanction the new work they required some evidence that no harm would ensue to the main channel. It was thus that the tidal model shown in Fig. 1 and described in the following article was built by the Civil and Mechanical Engineering Department of Southampton University under the supervision of Dr. W. Wright, A.M.I.C.E., then senior lecturer in civil engineering in the department. (Dr. Wright has since been appointed Professor of Civil Engineering at Trinity College, Dublin.)

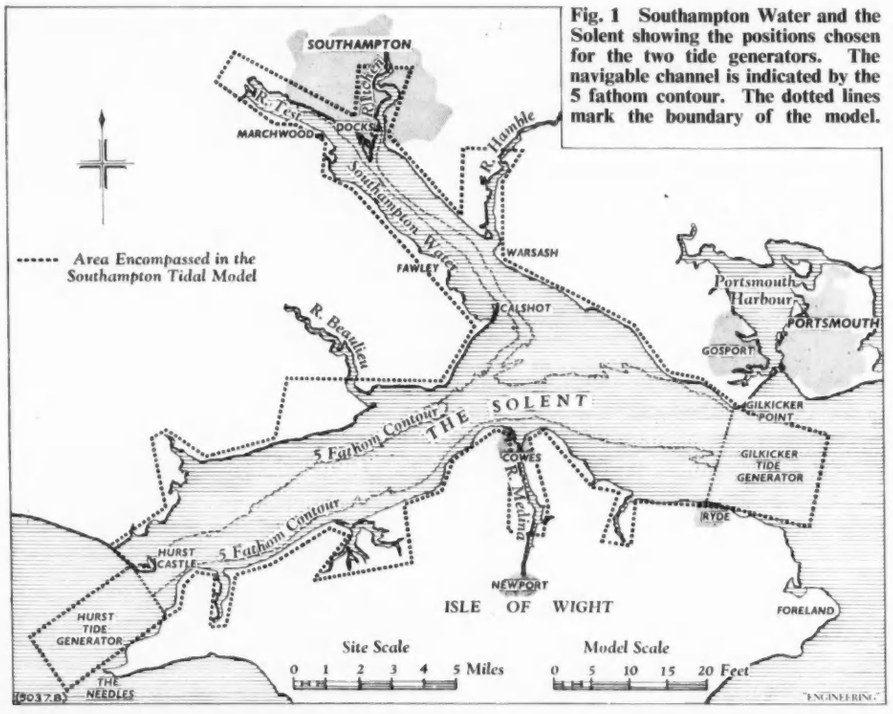


Fig. 1 Southampton Water and the Solent showing the positions chosen for the two tide generators. The navigable channel is indicated by the 5 fathom contour. The dotted lines mark the boundary of the model.

The request for the model was put forward in November, 1956, and, because information was urgently required, the whole project of designing the model and bringing it to satisfactory operation was completed in less than nine months. This need for speed influenced both the method of construction and of operation. The immediate and urgent question was whether the tides set up by the proposed work could possibly cause currents which would carry shingle into the main channel.

To provide the answer to this question the model was built with certain limitations: it has a fixed bed—this is satisfactory because of the stable character of the estuary bed—and it operates with a succession of only spring tides—representing the most severe condition that could occur. The model does, however, accurately reproduce the double tide of Southampton Water and is believed to be the first to simulate such a tide configuration. How it was brought to the condition that gave an adequate reproduction of the tides at the critical point is described below. A subsidiary experiment was undertaken in a flume to see if the currents set up were sufficient to move the shingle. In fact, the proposed works were shown to have no likelihood of causing such a movement; in addition, it was seen how the alignment of the jetty could be improved slightly and shown that the sailing conditions in the nearby Hamble

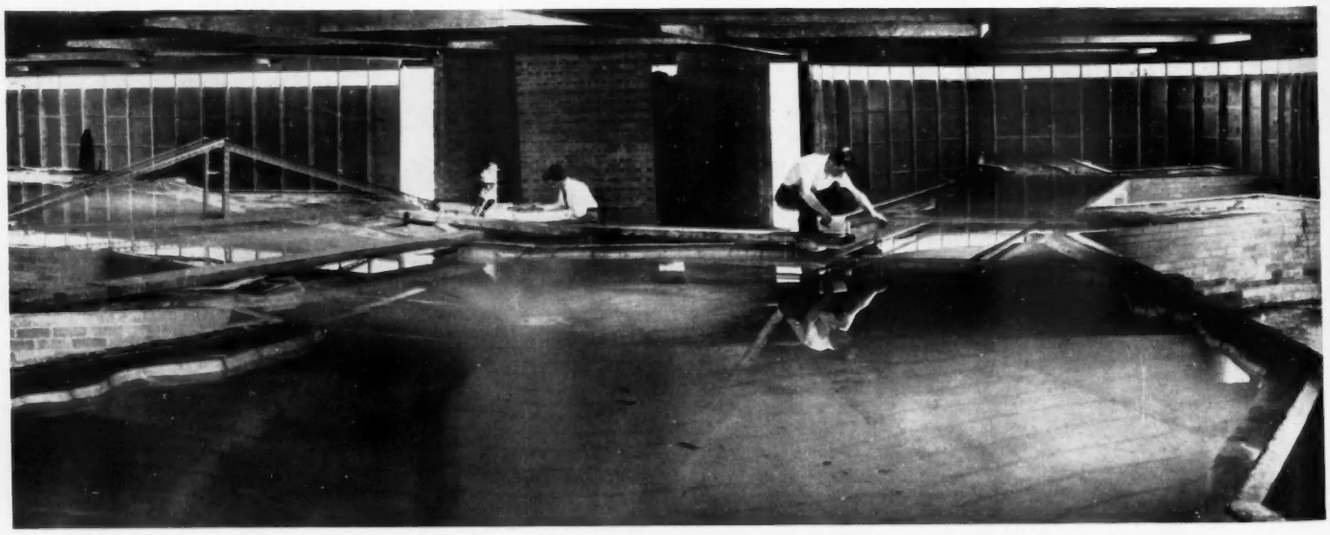


Fig. 2 A tidal model of Southampton Water has been built at the University to discover, initially, if the construction of a new jetty would cause any changes in the main channel. The model, the first known to take account of a "double tide," such as exists at Southampton, is shown here as it is seen from the Gilkicker tide generator, with Southampton Water and the dock area in the right-hand background.

river would be unaffected. (Incidentally, recent improvements in radio navigational aids in Southampton Water were the subject of an article in ENGINEERING for January 31, page 156.)

Now that the model has served its initial purpose Caltex have given it to the University where it will serve as an educational tool and be used to resolve a number of problems both of an *ad hoc* character and in fundamental hydraulic model theory. As a first measure, improved methods of tide control are being developed so that a higher accuracy in tide representation can be obtained over a greater extent of the model. In particular, provision has been made for simulating a flow of water round the Isle of Wight by installing a by-pass between the two tanks of the tide generators. The new methods of tide measurement will be the subject of a subsequent article.

Among the *ad hoc* problems which might be tackled for the Harbour Board are studies designed to improve the economy and effectiveness of the dredging and ship handling on falling or rising tides. The flow and movement of effluents discharged into the estuary could also be traced. Similarly, the movements of the condenser coolant from Marchwood power station could be checked; a rise of a few degrees in temperature downstream in the estuary might have one of several effects and these could be more accurately assessed. But whatever use it is put to, the model has already settled that the construction of the new jetty is feasible and saved its cost by indicating improvements in the jetty design.

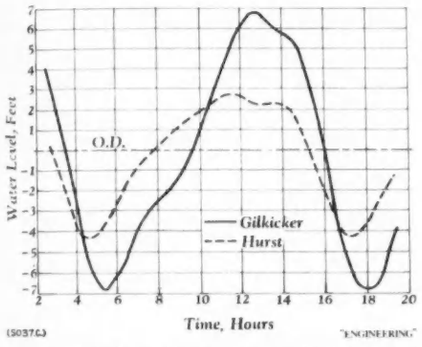


Fig. 3 Relative tide levels at Gilkicker and Hurst measured above Ordnance datum. The curves relate to a mean spring tide and, as can be seen, the Hurst tide leads by about 1 hour and has a much smaller range than that at Gilkicker.

DESIGNING AND BUILDING THE MODEL

By H. J. Sara, B.SC.(ENG.), A.M.I.MECH.E.*

The model of Southampton Water and its approaches was built to study the effects of some proposed dredging and jetty construction on the currents in the navigable channels. A fixed-bed model was chosen as the bed of the harbour is stable and not easily moved. It reproduces the effects of the tides, but not those of wind or waves.

Most harbours have a single connection with the open sea, and many models have been constructed, with satisfactory results, to meet this condition, the tide being simulated by some form of tide generator placed across, or just outside, the harbour mouth. In contrast, Southampton Water is unusual in that the Isle of Wight forms a barrier to direct entry of water from the English Channel, and there are thus two entrances, one at Portsmouth and one at the Needles, about 20 miles apart, as is shown in Fig. 1. The tides at these points are of different range and shape, and are approximately 1 hour out of phase, as is shown in Fig. 3. Two tide generators are therefore required, and it was decided to place these across the narrowest parts of the channels, i.e., at Hurst Castle and at Gilkicker Point.

Accurate records of tide level are available from recorders located at Hurst, Portsmouth, Calshot and Southampton Docks. These records are sufficient to enable the total volume of water in the enclosed area to be calculated at various times, and the mass flow rates into the area can be deduced. For a single-entry harbour this provides the information on which the tide generator is designed, and in many cases the calculated flows have needed little modification to give a true reproduction of real tides in the model.

When, as at Southampton, there are two entrances the mass flow, calculated from levels, can only be the algebraic sum of the flows through the two channels, and gives no information on the individual flows. Some further knowledge of water velocities is required. Current meters have been running at Hurst and Gilkicker and these records enable some estimate of the mass flows at these sections to be made, but these cannot be regarded as accurate with the same confidence as can be placed in level records, since velocities vary in magnitude across the section. The channel at Hurst, however, is narrow and deep and it was felt, and subsequently justified, that the flow calculation was fairly reliable. At Gilkicker the channel is wide, comparatively shallow and velocities change in direction at different parts of the tidal cycle, so that the calculated flows were not reliable.

MODEL SCALE

It is not practicable to use the same scale ratio for vertical and horizontal distances. This has been explained by Osborne Reynolds, the pioneer of hydraulic models, and later workers, but it is sufficient here to mention two principal reasons.

Depths are small compared with horizontal widths so that a true scale model which could be contained in a laboratory would have depths, and tidal ranges, too small to measure. In the Southampton model the extreme width from Hurst to Gilkicker is about 20 miles, while the navigable channel is about 40 ft. deep, and the tidal range about 14 ft. If the model were made 100 ft. wide the scale ratio would be about 1,000/1, the channel depth 0·04 ft. or 0·48 in. and the tidal range 0·014 ft. or 0·168 in. These would be almost impossible to measure, and variations, the detection of which would be necessary to prove the accuracy of the model, could not be detected. With these minute depths the flow in the model would be laminar, whereas the full-scale flow is almost entirely turbu-

* Lecturer in Mechanical Engineering, University of Southampton.

Fig. 4 (left) Part of the model, which has a fixed bed, during construction. The hardboard templates in the foreground have been placed in position, and those at the rear have been filled with rammed sand preparatory to applying the cement-mortar crust.

Fig. 5 (left) Southampton Docks on the model (empty) with the River Itchen behind. The river has been "curled up" to save floor space. The lines on the bed surface are the edges of the hardboard templates.

Fig. 6 (right) Southampton Docks and the River Test. A micrometer point gauge used for recording the tide curves can be seen in the background.

Continuing Tidal Model

lent. Velocity distribution, and hydraulic losses would not be to scale.

The scales chosen for the Southampton model are 1/1,250 horizontally and 1/100 vertically,thus giving a distortion of 12·5. The depths in the navigable channels are then about 4 in. and the tidal range for a 14 ft. tide is 1·68 in. As the velocity scale is dependent on the vertical scale and horizontal velocities are created by differences in water level, for a difference in level h the velocity v (with no friction) would be given by $v^2 = 2gh$. Hence, if h is reduced in the ratio of 1/100, v is reduced in the ratio $\sqrt{100} = 1/10$, i.e., model velocities are 1/10 of full scale.

The time scale follows from the horizontal and velocity scales; a particular particle of water must travel a corresponding distance in a corresponding time in both model and prototype. The model particle must thus travel 1/1,250 of the full-scale distance at 1/10 of full-scale velocity, which it will do in 1/125 of the full-scale time. A tidal cycle occurs in about 12·4 hr., which has been taken for model purposes as 12·5 hr., and the model tidal cycle (high water to high water) is thus 12·5/125 hr. = 6 minutes.

The model is constructed of rammed sand covered with a crust of cement mortar about 1 in. thick. It is contained within 4½ in. brick walls which roughly follow the shape of the water channels. The bottom is of concrete on hardcore, and the walls and bottom are lined with bitumen to form a watertight tank, though the sand and cement crust were not intended to be watertight and quickly became saturated. (When not working the model is kept full to eliminate cracking of the crust and to give support to the necessarily steep banks.) Hardboard templates at 1 ft. intervals were used for shaping the mortar to its final form, as shown in Fig. 4, and the templates have remained permanently in the model. They can be seen in Fig. 5 as lines on the model surface.

The templates—there were 574 in all—were made and placed to an accuracy of 0·01 in. vertically. Horizontal positioning proved to be less accurate as templates tended to be moved slightly during filling in. Construction of the model, and the building to contain it went on simultaneously.

TIDE GENERATION

The duty of the tide generator is to produce effects in the model which are produced in the full scale by the changes in the open sea outside the harbour. This is done by alternately abstracting and supplying water to produce the seaward and landward flows through the harbour mouth. In the Southampton model, with the scales chosen, about 200 cub. ft. (5 tons) of water have to be removed and returned by each generator in each 6 minute cycle.

Several methods have been used successfully in other models:

(i) *The Displacer.*—In this a plunger is raised and lowered in a tank to simulate the sea outside the model proper, displacing the volume of water which has to flow through the harbour mouth. The plunger is driven up and down, either directly by a cam rotating once per cycle or by a servo-motor controlled to give the required displacement.

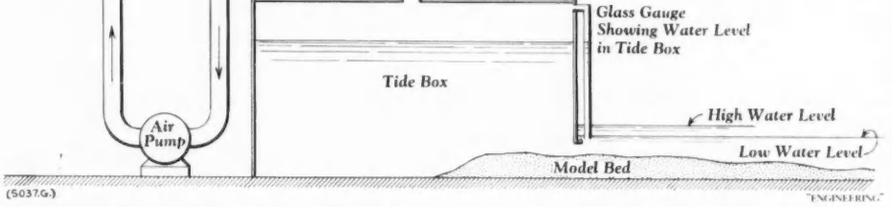


Fig. 7 The tide generators: the air pump extracts air at a constant rate from the tide box, but the rate at which air enters the box is controlled by the position of the butterfly valve. Opening the butterfly allows air to flow in more quickly than it is being removed, and water flows out of the box into the model, so raising the water level. Closing the butterfly similarly tends to lower the water level.

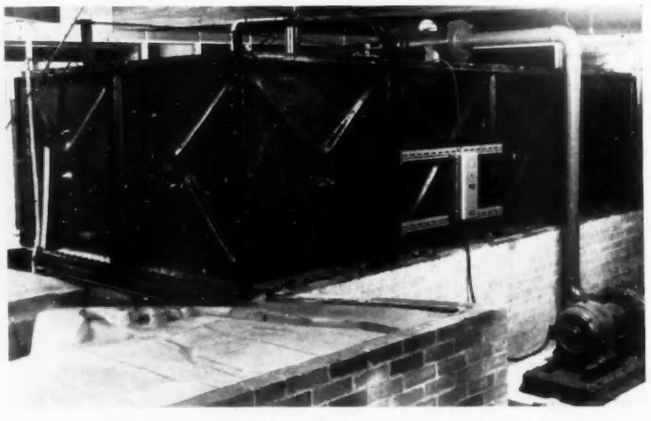


Fig. 8 (above) The Hurst tide generator. The air pump is on the right; on top of the tide box is the butterfly valve and its operating gear. To the left can be seen the hand lever used to operate the valve in the initial stages of developing the cam which ultimately actuated the valve.

With either method of driving the force to be applied would be considerable for a model of the size required, and a robust and fairly complicated mechanism would have to be made.

(ii) *Direct Pumping of Water.*—Several arrangements may be used, but the general principle is that water is pumped from a sump at a constant rate into the model and a varying amount is allowed to flow back into the sump. The rate of return flow is controlled by a valve, or movable weir, so operated as to generate the correct net flow into the model to produce the tides. The weir or valve needs fairly robust operating gear, and unwanted water currents may be set up in the model.

(iii) *Pneumatic Method.*—This was the method chosen for the Southampton model.

The principle of operation is that water is sucked up into an inverted tank or bell by pumping out the air, and allowed to return by admitting air. As shown in Fig. 7, air is continuously removed from the tank by the air pump, and a butterfly valve allows air to flow in from the atmosphere. By changing the rotation of the valve the water level in the tank can be made to rise or fall, thus controlling the tides in the model.

The moving parts are the air pump and valve, both of which may be much lighter than the mechanisms in (i) and (ii). High velocities are confined to the air, and there is no tendency to set up unwanted currents in the water. A major advantage is that the valve can be balanced so as to require a very small operating force. The pneumatic method was first used at the Hydraulics Research Station at Wallingford.*

The Wallingford pneumatic system used a centrifugal fan to provide the continuous pumping of air from the tank. The discharge rate from this was a function of the air pressure, which was determined by the height of water in

* M. J. Wilkie and G. A. J. Young, *The Engineer*, July 25, 1952.

Fig. 9 (right) The butterfly valve with its operating cam and lever behind. The shaft in the foreground is connected to the hand lever and operated the valve in the initial development of the cam. It is normally disconnected.

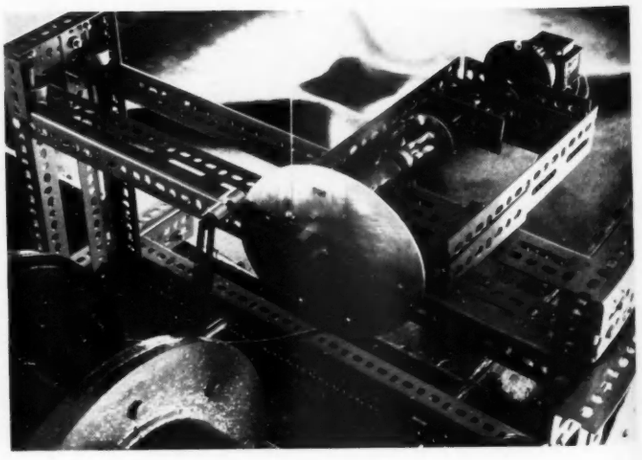


Fig. 10 (right) The cam, follower, and drive motor. The synchronous motor at the rear drives the cam through the gear train to give a speed of 1 revolution in 6 minutes.

the tank. Moreover, the maximum head of water which can be producedby an air fan at constant speed is limited. In consequence, the possible rate of flow of water which can be produced is much less when the tank is nearly full than when the water level in it is lower. For these reasons it was believed that a positive pump of the eccentric vane or Roots blower type would be more useful, since the rate of air flow is then almost independent of pressure and, in the range required, there would be no limit to the height to which water could be raised in the tank.

It was estimated that the maximum flow to be handled by each tide generator was about 150 cub. ft. per minute. The air pump capacity had to exceed this figure, but was not otherwise critical. Two Reavell vane type blowers giving 200 cub. ft. per minute at 1,450 r.p.m. were made available by the Southampton Harbour Board. (They had previously been employed for blowing ballast tanks in a section of a Mulberry Harbour now used as a pontoon.)

The tanks for the model were built of Braithewaite 4 ft. square steel panels above 9 in. brick walls forming an extension of the model. The bitumen lining was carried over the top of the walls and the joint with the steel made with the same compound as was supplied for jointing the tank panels. Steel angles were used to brace the sides and top of the tank. The height of 4 ft. was somewhat greater than required, but the convenient erection of the sectional tank was a great advantage. The Hurst tank, which is illustrated in Fig. 8, is 16 ft. by 8 ft. in plan and that for Gilkicker is 12 ft. by 12 ft., the difference being due to the different channel widths at these sections.

The butterfly valves are 5 in. in diameter, and are circular. Since they are never required to close completely, there was no advantage in using the usual elliptical shape. Ball bearings were used to mount the spindles and care was taken to avoid actual contact between the valve and pipe, thus keeping friction to a minimum. The size of valve was decided from tests on a 2 in. model and the size chosen to give about 45 deg. of movement for the control lever operating the valve. The pipes connecting the valves and pumps are 4 in. in diameter.

The suction and discharge pipes are taken outside the building, to reduce noise and to avoid any contamination of air with oil from the blowers. Burgess silencers of the straight-through type are fitted to the ends of the suction and discharge pipes and have proved effective in suppressing noise to an acceptable level.

CONTROL MECHANISM

It had been intended to operate the model by an electronic servo system. This would use a chart of a whole series of tides from neaps to springs and control the butterfly valves so as to keep the water in the model just outside each tide generator at the level corresponding to that time on the chart. This system, however, could not be developed in the time available, and was postponed until the original series of tests had been completed. (It is hoped to publish a later article describing a modified system, which is still being perfected.)

The mechanical system adopted is direct operation of a lever on the butterfly valve shaft by a cam driven at 1 rev. in 6 min. by a reduction gear from an Everett Edgecombe Synelock synchronous motor working on the 50 cycle mains. The mechanisms are to be seen in Figs. 9 and 10. This ensures that the cam on each tank is effectually geared with the other and will not get out of phase. No attempt is made to produce a cycle of tides, but a single spring tide, representing the most severe condition to be experienced, is repeated indefinitely.

The cams have a base circle of 4 in. diameter, and a lift of about 3 in. They are made of hardboard, which is strong enough to carry the light roller load, and new cams can be readily cut or altered using an electric hand jig saw. The method of obtaining the cam profile was by successive correction until the required tides were obtained, but the general shape was determined as follows.

From the known current meter readings taken on the full scale at the tide generator positions, it was possible to calculate approximately how much water should be in each tide tank at any time, and thus a scale could be fixed to the tank gauge glasses showing where the water should stand at successive time intervals. A hand lever about 7 ft. long was connected to an extension of the butterfly spindle so that an operator could stand by the gauge glass and control the butterfly in order to bring the gauge reading to the correct level at the correct time. After some practice it was found that reasonably accurate control by hand was possible. The roller on the butterfly lever was replaced by a pencil which pressed against a blank cam disc, and with the synchronous cam-driving motors running, the profile of the cam was thus traced out to reproduce the hand operation of the butterfly. The cam was then cut out in hardboard.

It was intended to correct the cams thus obtained so as to give the correct levels at Hurst and Gilkicker throughout the cycle but, such is the complexity of the tides, this proved too difficult as it was never clear which cam should be altered to produce a particular change of level.

The technique finally adopted was to assume the full-scale current meter readings at Hurst were the mean velocities across the section, which seemed reasonable for such a deep narrow channel. Then, with the Hurst tide generator working, but Gilkicker generator stopped, the Hurst cam was modified until the model currents at Hurst agreed with the full-scale readings. The Gilkicker generator was then run and its cam modified until the tide levels at Calshot (which was the nearest gauging station to the area for which tests were required) were in agreement with the full scale. For this section of the work cams of heavy cardboard were used, so that modified cams could be cut quickly with scissors.

When the Calshot levels were nearly correct the currents at Hurst were checked, and the cam at Hurst slightly altered, since the modification at Gilkicker did have some effect on the Hurst currents. The Gilkicker cam was then brought to the final correct form to give the correct Calshot levels. The degree of agreement reached is illustrated in Figs. 11 and 12. It was found that the levels at Southampton were then also almost correct, and within 2 per cent. at the critical region of the proposed jetty. The cardboard cams were then copied in aluminium, which appears in the illustration.

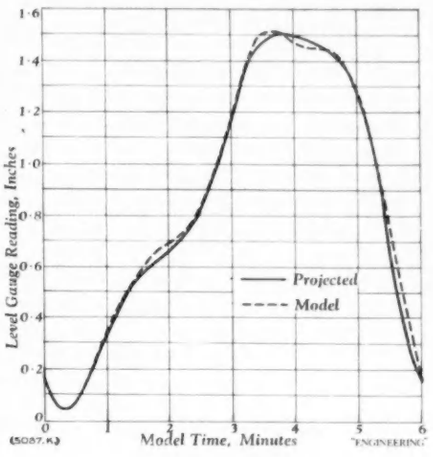


Fig. 11 Calshot.

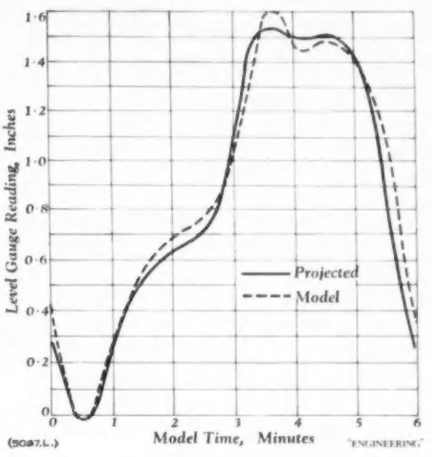


Fig. 12 Town Quay.

Figs. 11 and 12 The tidal curves at Calshot and at Southampton (Town Quay) actual and from the model. It will be seen that although precise agreement has not been obtained, the well-known double tide of Southampton Water appears on the model, and is in fact somewhat exaggerated. In development of the model tide considerable effort was required to suppress its tendency to produce a very large double tide.

Further checks on the model were made by tracing spars floating in the water, and these were found to agree with those on the full scale. Velocity directions were measured by a celluloid "weather-vane" and velocities were also measured by current meter. This meter was generally similar to those developed by the Hydraulics Research Station at Wallingford.* The meter is briefly described as follows.

The current is measured by counting, over a period of ten seconds, the revolutions of a small propeller blade immersed in the current; the small size of the propeller and low water velocities preclude any form of mechanical counter which would offer too much resistance to the turning of the propeller. The count is therefore shown on dekatron tubes in which the glow rotates through ten positions on each of three tubes which count the hundreds, tens and units respectively. After the counting period of ten seconds, the tubes are left for about seven seconds so that they can be read before being reset to zero ready for the next count. A complete cycle takes 20 seconds, so that 18 readings are given in the complete tidal cycle of 6 minutes. A tell-tale light shows as follows: out during counting, on during the reading period, out when the counters reset, and a short flash on just before the next counting period. This tell-tale is especially useful in tracing the cycle during periods when the tide is slack and the propeller is turning very slowly, or not at all.

The indicated count is actually not complete revolutions, but passages of individual propeller blades, of which there are five. The following remarks describe the method of operation. The element supporting the propeller unit is coaxial cable, the core of which has a bare end situated very close to the path of the propeller blades. The electrical circuit between the core and outer conductor is completed by the water, and the electrical resistance of this water is increased when the propeller blade (which is non-conducting) is opposite the end of the core, since the blade displaces part of the water conductor. The apparatus detects and counts these resistance fluctuations.

After the model was brought to the state of representing the full-scale conditions with sufficient accuracy, it was modified to reproduce the proposed dredging operations which, as has been previously noted, were shown to have no harmful effect on the amentities of the Hamble River or on the main shipping channel.

* "Miniature Liquid Flow Meter," Dedaw and King, ENGINEERING, vol. 178, page 396 (1954).

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers
NEWCASTLE-UPON-TYNE
"Turbine Supervisory Equipment," by E. D. Kelly. Tyneside Branch. Crown Hotel, Clayton-street west, Newcastle-upon-Tyne. Tues., Feb. 18, 7.30 p.m.

British Computer Society
LONDON
"Mental Arithmetic: An Historical Review with Demonstrations," by Professor A. C. Aitken. Caxton Hall, off Victoria-street, S.W.1. Mon., Feb. 17, 6.15 p.m.

British Institution of Radio Engineers
BIRKENHEAD
"Closed-Circuit Television," by J. G. M. Downes. Merseyside Section. Birkenhead Technical College, Birkenhead. Wed., Feb. 19, 7 p.m.
EDINBURGH
"Frequency Response Instrumentation for the Analysis, Design and Production of Servo-Mechanisms," by G. R. Swainston. Scottish Section. Department of Natural Philosophy, The University, Edinburgh. Fri., Feb. 21, 7 p.m.
GLASGOW
"Frequency Response Instrumentation for the Analysis, Design and Production of Servo-Mechanisms," by G. R. Swainston. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Feb. 20, 7 p.m.

Building Centre
LONDON
Films: "Keeping Houses Warm" and "House Foundations on Shrinkable Clays: Methods and Costs," exhibited by the Building Research Station. Wed., Feb. 19, 12.45 p.m.

Chemical Society
BELFAST
"Role of the Analyst in the Nuclear Power Programme," by F. J. Woodman. Northern Ireland Branch. Queen's University, Belfast. Tues., Feb. 18, 7.45 p.m.
BRISTOL
"Reactions of Atoms and Free Radicals," by Professor J. C. Robb. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., Feb. 20, 5.15 p.m.

Diesel Engineers and Users Association
LONDON
"Engine Evolution: Non-Marine Engines Over a Quarter of a Century," by D. S. D. Williams. Caxton Hall, off Victoria-street, S.W.1. Thurs., Feb. 20, 2.30 p.m.

Engineers' Guild
BRISTOL
Luncheon Meeting. Western Branch. The Berkeley, Clifton, Bristol. Thurs., Feb. 20, 1 p.m.

Illuminating Engineering Society
MANCHESTER
"Lighting at London Airport," by J. G. Holmes. Manchester Centre. Offices of the North Western Electricity Board, Town Hall, Manchester 2. Thurs., Feb. 20, 6 p.m.*

Incorporated Plant Engineers
BLACKBURN
"Nuclear Reactors for Power Production," by J. A. Dixon. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., Feb. 20, 7.30 p.m.
ROCHESTER
"Applications of Photography in Science and Engineering," by J. F. Padday. Kent Branch. King's Head Hotel, High-street, Rochester. Wed., Feb. 19, 7 p.m.

Institute of Fuel
LONDON
Melchett Lecture for 1957 on "Nuclear Power Development: Some Experiences of the First Ten Years," by Sir Christopher Hinton. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Feb. 19, 5.30 p.m.*
CHESTER
"Coal and Oil as Partners in Energy Supply," by Dr. R. R. Gordon. North Western Section. Blossoms Hotel, Chester. Wed., Feb. 19, 7.30 p.m.
SHEFFIELD
Discussion on "Operational Experience at Calder Hall." Yorkshire Section. Royal Victoria Hotel, Sheffield. Tues., Feb. 18, 7 p.m.

Institute of Marine Engineers
BIRKENHEAD
"Marine Lubrication," by G. H. Clark. Merseyside and North Western Section. Birkenhead Technical College, Birkenhead. Wed., Feb. 19, 7.15 p.m.

Institute of Marine Engineers and Institution of Naval Architects
PORTSMOUTH
"Nuclear Power for Ship Propulsion," by Dr. S. L. Smith. Southern Joint Branch. Portsmouth College of Technology, Portsmouth. Mon., Feb. 17, 7.30 p.m.

Institute of Metals
BIRMINGHAM
"Neutron Irradiation Effects in Metals," by Professor J. G. Ball. Birmingham Local Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham 2. Thurs., Feb. 20, 6.30 p.m.

Institute of Physics
LONDON
Annual General Meeting. "High Polymer Properties and Structure," by Dr. A. H. Willbourn. London and Home Counties Branch. Wed., Feb. 19, 6 p.m.*
"Electronic Devices in Telephony," by Dr. J. E. Flood. Electronics Group. Tues., Feb. 18, 5.30 p.m.*
EDINBURGH
"The Electronic Computer in Industry," by R. H. Tizard. Scottish Branch. Department of Natural Philosophy, The University, Edinburgh. Mon., Feb. 17, 7.15 p.m.
GLASGOW
"The Electronic Computer in Industry," by R. H. Tizard. Scottish Branch. Department of Natural Philosophy, The University, Glasgow. Tues., Feb. 18, 7.15 p.m.

Institute of Road Transport Engineers
LONDON
"The Free-Piston Gasifier," by B. C. Lovatt. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., Feb. 20, 6.30 p.m.
EDINBURGH
"Adaptation of Commercial Vehicles for Use in a Special Purpose Mixed Fleet," by R. H. R. Hacker. Scottish Centre. North British Hotel, Edinburgh. Mon., Feb. 17, 7.30 p.m.
LEEDS
Air Brakes and Auxiliaries for Commercial Vehicles," by W. A. Kirk. Yorkshire Centre. Great Northern Hotel, Wellington-street, Leeds, 1. Thurs., Feb. 20, 7.30 p.m.

Institution of Chemical Engineers
MANCHESTER
Symposium on "Tools of Chemical Production Management." North Western Branch. Reynolds Hall, College of Science and Technology, Manchester. Tues., Feb. 18, 3 p.m.

Institution of Civil Engineers
LONDON
"Jodrell Bank Radio Telescope," by H. C. Husband. Tues., Feb. 18, 5.30 p.m.*

Institution of Electrical Engineers
LONDON
"Magnetic Tape for Data Recording," by Dr. C. D. Mee (read by J. F. Doust). Measurement and Control Section. Tues., Feb. 18, 5.30 p.m.*
"Relation Between Picture Size, Viewing Distance and Picture Quality, with Special Reference to Colour Television and Spot-Wobble Techniques," by L. C. Jesty. Radio and Telecommunication Section. Wed., Feb. 19, 5.30 p.m.*
CARLISLE
"Earthing of Low-and Medium-Voltage Distribution Systems and Equipment," by F. Mather. North Eastern Centre. Carlisle Technical College, Carlisle. Fri., Feb. 21, 7 p.m.
LIVERPOOL
Discussion on Report on "Supply and Training of Teachers for Technical Colleges," opened by Dr. Willis Jackson. Mersey and North Wales Centre. Royal Institution, Colquitt-street, Liverpool. Mon., Feb. 17, 6.30 p.m.
NOTTINGHAM
Faraday Lecture: "Electrification of the British Railways," by the late G. H. Fletcher, delivered by R. Ledger. East Midland Centre. Albert Hall, Nottingham. Thurs., Feb. 20, 7.15 p.m.*

Institution of Heating and Ventilating Engineers
SHEFFIELD
Discussion on "Hot-Water Heating Systems Employing Small Bore Pipes." Yorkshire Branch. Royal Victoria Station Hotel, Sheffield. Wed., Feb. 19, 7.30 p.m.

Institution of Mechanical Engineers
LONDON
Discussion on "Extent to Which Standardisation Should be Pursued in the Motor Industry." Automobile Industry. Tues., Feb. 18, 6 p.m.*
Steam Group Discussion. Wed., Feb. 19. *Postponed* until April 22.
"Packed Glands for High Pressures: An Analysis of Fundamentals," by Professor J. L. Thomson; and "Glands for the Entry of Electrical Cables into Pressure Vessels Containing or Surrounded by Conducting Liquids," by H. H. Grunwald. Fri., Feb. 21, 6 p.m.*
CHATHAM
Thomas Lowe Gray Lecture: "Machinery for Cross-Channel Passenger Ships," by E. L. Denny. Southern Branch. Sun Hotel, Chatham. Wed., Feb. 19, 7.30 p.m.
LEICESTER
"Influence of Dynamics in High-Speed Machinery," by S. A. Makovski. East Midlands Branch. Bell Hotel, Leicester. Wed., Feb. 19, 7.15 p.m.
MANCHESTER
"Radioisotopes in Engineering," by J. L. Putman. North Western Branch. Engineers' Club, Albert-square, Manchester. Thurs., Feb. 20, 6.45 p.m.

Institution of Mining and Metallurgy
LONDON
Various short papers. Geological Society, Burlington House, Piccadilly, W.1. Thurs., Feb. 20, 5 p.m.*

Institution of Production Engineers
LONDON
"Research on Modern Metal-Cutting Techniques," by J. Cherry. London Section. Royal Empire Society, Northumberland-avenue, W.C.2. Thurs., Feb. 20, 7 p.m.
BELFAST
"Machining Techniques for Non-Ferrous Materials," by S. Radcliffe. Northern Ireland Section. Kensington Hotel, Belfast. Thurs., Feb. 20, 7.30 p.m.
LINCOLN
"Computer Control of Machine Tools," by M. Monk. Lincoln Section. Ruston Club, Lincoln. Thurs., Feb. 20, 7.30 p.m.

Institution of the Rubber Industry
LIVERPOOL
"Rubber and Plastics Machinery," by K. M. Wilson. Exchange Hotel, Liverpool. Mon., Feb. 17, 7.15 p.m.

Institution of Structural Engineers
BIRMINGHAM
"Recent Building in Northern Europe," by G. Winteringham and Bryan W. Cooper. Midland Counties Branch. Royal Birmingham Society of Artists' Galleries, New-street, Birmingham. Fri., Feb. 21, 6 p.m.

Junior Institution of Engineers
LONDON
"Instrumentation in the Gas Industry," by T. A. Lucas. Fri., Feb. 21, 7 p.m.*

North East Coast Institution of Engineers and Shipbuilders
NEWCASTLE-UPON-TYNE
"History and Development of Hydraulic Transmissions for Marine Propulsion," by D. Firth. Mining Institute, Westgate-road, Newcastle-upon-Tyne. Fri., Feb. 21, 6.15 p.m.

North East Metallurgical Society
MIDDLESBROUGH
"Modern Developments in Iron and Steelworks Refractories," by H. M. Richardson. Cleveland Scientific and Technical Institution, Middlesbrough. Tues., Feb. 18, 7.15 p.m.

Royal Aeronautical Society
LONDON
"Aero-Elastic Problems Associated with High Speeds and High Temperature," by E. G. Broadbent. Tues., Feb. 18, 7 p.m.

Royal Meteorological Society
LONDON
Various short papers. Wed., Feb. 19, 5 p.m.*

Royal Society
LONDON
"Recent Advances in Nuclear Physics," by R. E. Peierls, D. H. Wilkinson and W. E. Burcham. Thurs., Feb. 20, 4.30 p.m.*

Royal Society of Arts
LONDON
"Rocket Propulsion," by J. E. P. Dunning. Wed., Feb. 19, 2.30 p.m.

Royal Statistical Society
LONDON
"Research in Statistics," by Professor M. G. Kendall. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Feb. 19, 5.15 p.m.*

Scientific Film Association
LONDON
"Industry Communicates by Film," introduced by Geoffrey Bell. Mezzanine Cinema, Shell-Mex House, Strand, W.C.2. Thurs., Feb. 20, 6.30 p.m.

Sheffield Metallurgical Association
SHEFFIELD
"Low Carbon Bainitic Steels," by Dr. K. J. Irvine. The University, St. George's-square, Sheffield. Mon., Feb. 17, 7.30 p.m.

Society of Chemical Industry
LONDON
"Corrosion of Spraying and Dusting Machinery," by R. J. Courshee. Mon., Feb. 17, 6 p.m.

Society of Instrument Technology
NEWCASTLE-UPON-TYNE
"Application of Oxygen in Industry," by J. Harrison. Newcastle Section. King's College, Stephenson Building, Newcastle-upon-Tyne. Wed., Feb. 19, 7 p.m.

South Wales Institute of Engineers
CARDIFF
"Breaking of Coal by High-Pressure Compressed Air," by P. G. Weekes and A. M. Watkins. Thurs., Feb. 20, 6 p.m.

Women's Engineering Society
MANCHESTER
"Fuel Efficiency," by Miss M. C. Cowpe. Manchester Branch. Estate Exchange, 46 Fountain-street, Manchester 2. Tues., Feb. 18, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Computer Society, 29 Bury-street, St. James's, London, S.W.1.
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Diesel Engineers and Users Association, 19 Old Queen-street, London, S.W.1. (TRAfalgar 5597.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (BELgravia 6111.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
North East Metallurgical Society. Apply to Mr. A. H. Burn, 35 Central-avenue, Billingham, Co. Durham.
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Scientific Film Association, 164 Shaftesbury-avenue, London, W.C.2. (TEMple Bar 4694.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield, 10. (Sheffield 62144.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
South Wales Institute of Engineers, Park-place, Cardiff. (Cardiff 23296.)
Women's Engineering Society, 25 Foubert's-place, London, W.1. (GERrard 5212.)

The Human Element

Agonising Arbitration

The arbitrator's task during the next few months will be the envy of no one. The Government clearly hope that the trade unions will be "reasonable," remembering that the nation's major ill is inflation. The parties have long been accustomed to compromise but from now on any award lower than a "reasonable" claim will be a nail in arbitration's coffin. A nervousness is speeding through the ranks of organised labour and it concerns the prospects of unemployment, not inflation. Parallels are drawn, which are inadmissible with, for example, the United States or Germany. Many forget that this country is hopelessly dependent on being competitive in export markets.

The first major arbitrations to be heard since the Government statements on wage inflation last October have resulted in awards ranging from 23*s.* 6*d.* to 7*s.* a week. The arbitrators were the Civil Service Arbitration Tribunal and the parties concerned the General Post Office and the Post Office Engineering Union. Fifty thousand engineering workers win increases which will be back-dated to July, 1956, and a further 25,000 will be affected. The cost of these awards will amount to £3½ million in a full year but already it has been covered by increased telephone and other charges.

In all or most of the wage claims which go to arbitration there is the cost-of-living rise to consider. Arbitrators have no mandate to reduce the standard of living of British workers: unemployment or short time must do that if it has to be done. But this time the tribunal have had recommendations by the Civil Service Pay Unit to go on. These have followed the "Priestley formula" of the Royal Commission on the Civil Service and are doubtless a very fair solution to the dispute between the two parties. Thus, the unions may gladly note, the Government policy of the moment does not preclude the implementation of carefully thought out proposals for the reform of wage structures. But in this case, alas, wages must be revised upwards to be fair.

Less Overtime and Why

Overtime is on the decline and the main reason so far appears to be increased productivity. The investment boom of 1955 to 1956 has enabled most manufacturing industries to produce more in less working hours. In the last week of November, 12·62 million man-hours of overtime were worked, compared to 12·69 million man-hours in the corresponding week of 1956 and 14·34 million in 1955. But whereas the steep fall in 1955/56 was accompanied by a fall of nearly 1 per cent. in industrial production, the decline last year corresponded to a rise of 1½ per cent. in production.

It would seem to follow from these figures that the new investment now coming into full production is mainly responsible, but an additional factor may be the fact that most mass-production industries are working to full capacity, for example, motor vehicles and household appliances, whereas in 1955/56 they were not. But too much should not be read into the figures. Overtime working represents at most no more than 3 per cent. of the total working week.

Severed Head

The Government's decision not to fill the post of Director General of Works at the Ministry of Works on the retirement of Sir Charles Mole has drawn a most vigorous protest from the Institution of Professional Civil Servants. A leading article in the February issue of *State Service* roundly condemns the Government for leaving vacant "for an indefinite period" a key post at a time when "Sputniks circle the earth and almost every Minister of the Crown, as well as other responsible men and women, testifies to the importance of technically qualified persons and to the necessity for the professionally and scientifically qualified being brought into management."

The Institution clearly takes a most serious view of this type of action, which to them is a major issue because the reason for not filling the post is the difficulty of finding suitable applicants at present-day rates of pay. The Institution sent a deputation to see the Minister of Works, who appeared not to appreciate "the extraordinary character of his decision." What it means in fact is that the deputy to Sir Charles Mole will bear the full burden of the professional direction of the work. But he will carry on without being able to exercise the full responsibility, without receiving public acknowledgment of the work he will have to do, and without being able to draw the salary for the post.

Training the Teachers

Steps are now being taken to implement the recommendations of the committee set up by the Ministry of Education under the chairmanship of Dr. Willis Jackson which was concerned with the supply of teachers in technical colleges. The number of places available for those who wish to train as technical teachers is to be raised by over 60 per cent. and larger grants are to be paid by the Ministry to students.

The Ministry points out that bigger grants are needed since people from industry and commerce have to be attracted to fill the positions. A married man with one or more children will receive a grant while attending the pre-service course which will make him no worse off than if he were getting the basic minimum salary of a grade A assistant in a technical college, that is to say, £475 a year.

The terms are probably a minimum for the task to be carried out, which is no bad thing when public money is involved. Nevertheless, the salary offered (for such it is in effect) shows the yawning gap which exists between teaching and industry so far as remuneration is concerned. In theory the best are wanted to teach the young and those who have some sense of dedication towards education. It will have to be admitted, however, as the technical training programme gathers momentum that teachers will have to be recruited from something less than the second best and the courses adjusted accordingly. If the teaching cannot always be inspired then let it be at least well organised and according to an efficient system of curricula.

Humbug for Apprentices

It is becoming increasingly apparent that the long-term success or failure of this country's technical training programme is going to depend on the more rapid and efficient training of apprentices. This is so for two reasons. First, it is necessary to get young men trained more quickly into skilled trades. Second, if the training period can be reduced it will make skilled employment that much more attractive.

Those who preach such doctrine, however, are faced with a long tradition of inefficiency and humbug. The fact is that the apprenticeship system has for centuries been partly an inefficient method of training for a craft and partly an efficient method of protecting the journeyman. Just how difficult it is going to be to make any serious changes can be seen from the current dispute between the Electrical Trades Union and the National Federated Electrical Association. The N.F.E.A. is trying to establish two grades of trainee in an effort to weed out the poorer material or at least prevent it from holding back the brighter boys. The E.T.U. smells a rat and wants a national central system of apprenticeship registration which would obviously be costly, unwieldy, but would give the E.T.U. closer control of apprenticeship at the centre.

This issue is a difficult one. There are centuries of suspicion to be broken down on either side if progress is to be made. For industry in general the best way to start might be to go for quicker training rather than more apprentices, though clearly these two add up to the same thing in the end.

Summat and Nowt

It has been announced that Leeds University will shortly issue the results of its research into dialects in the form of a dialect atlas. The work has been done by two research workers with funds supplied by the Leverhulme Trust. The purpose of it has been to record dialect words before they finally pass out of currency.

It is easy to be sentimental about dialect. It thrives among isolated communities and when this isolation begins to break down, standard speech sets in. There is much lost in the change, but the technical man, least of all the engineer, is hardly likely to sigh overmuch about it. Industry's efforts to build up standard terms in the interests of clarity and accuracy have been much impeded by local usage. Industries like cotton and mining have clung to terms (because the local trade wanted to) which have made the technical man's life a good deal more difficult. In its extreme form, where dialect becomes a language, comic effects have been achieved by trying to stretch idiom beyond its power to describe technicalities. There are still those who would try to put abstruse physical or chemical theory into Erse and Gaelic while others have insisted that "screwdriver" can be adequately expressed phonetically in Hausa. The brutal fact is that if we want mass-produced goods by mass-produced standards we must have a mass-produced language. Such things, however, make our renderings of "On Ilkla Moor baht 'at" and "My Old Dutch" all the more precious—in every sense of the word.

The Cow's in the Meadow

In a poster newly displayed at all Underground stations, London Transport make their point concerning the difficulty of running trains to schedule under rush hour conditions. "The capacity of a line," says the poster, "however technically perfect, depends on the orderly speed of its passengers."

The enjoining shouts of the employees so familiar to Londoners—"Let 'em off first, please," "Hurry along, there," "Stand clear of the doors"—are to be reinforced by a Klaxon horn. The insistence of passengers to get on a train at all costs, and the not unfamiliar sight of officials walking along the whole length of the train to find which door is prevented from closing by overflowing humanity, cost extra trains at the most critical periods. This in turn makes worse the overcrowding and waiting which rush-hour travellers must grin and bear whatever London Transport try to do.

The Board will doubtless be attacked for allowing more beastly noises to crowd in, as if the harassed traveller had not enough already of the raucous shouts of London Transport staff. But so far it is only an experiment—at several stations including Liverpool Street—and will only become general if it succeeds. In that case few will mind the authoritative admonition and urgent warning of a Klaxon horn.

Atomic Review

Concentrated Solution

PHYSICAL reactions play so fundamental a part in atomic energy work that the importance of chemical reactions is sometimes overlooked. Without chemical separation, the accumulation of neutron-absorbing fission products in nuclear fuels would lead to great wastage of fissile and fertile materials. Because there are many different fission products, in addition to the fissile plutonium produced by irradiation of uranium 238, the problems of separation are complex. These problems may be said to have been in solution for a long time (since plutonium was first required for nuclear weapons). At the recent British Nuclear Energy Conference "Symposium on Nuclear Energy," fuel processing was discussed at length, and a summary of the papers with background notes appears below. Attention is drawn to the search for a process in which the products remain in solution until the final stages; clearly continuous processing is simpler where only liquids are involved.

Fuel processing is an essential feature of an integrated nuclear power scheme, and we have therefore asked Mr. G. W. K. Ford, who is concerned with experimental work on the possible inadvertent occurrence of criticality in processing plants, and who attended the B.N.E.C. symposium, to review the papers on the subject which were presented there. The first part of the summary appears below.

Production of Pure Fissile Materials

It will doubtless be recalled that for the purposes of producing fissile materials for military purposes the United States Manhattan project was confronted with two possible approaches: (*a*) the direct separation of the uranium 235 isotope from the co-existent and chemically identical uranium 238 by some physical process, such as thermal or gaseous diffusion, or the electromagnetic method; or alternatively (*b*) the production of the artificial element plutonium from the fertile uranium 238 using neutrons evolved in fission of uranium 235 in natural-uranium-fuelled, graphite-moderated production reactors, followed by the separation by chemical methods of the plutonium from the chemically different uranium (and also from the associated fission products).

It was decided to develop both types of process simultaneously and success was achieved in both projects. There are many considerable technical problems in both systems, and in the plutonium system by no means the least of these is the chemical separation of the radio-biologically toxic (alpha-active) plutonium from the highly radioactive (gamma and beta emitting) "ashes" of the pile fuel. It is with some of these processes that six of the seven papers[1, 2, 3, 4, 5, 6] presented to the B.N.E.C. symposium sponsored by the Institution of Chemical Engineers and held on January 21 at Church House, Westminster, were concerned.

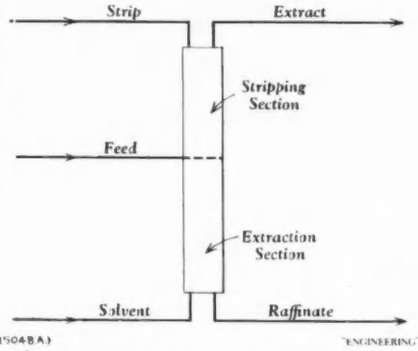


Fig. 1 Centre-fed counter-current extractor used in the separation of uranium and plutonium from fission products in reprocessing nuclear fuels.

Essence of the Problem

The irradiated fuel from the plutonium-production pile consists of uranium metal rods, a fraction of a per cent. of which has been converted into plutonium metal and some 40 or more radioactive fission-product elements. Essentially, it is desired to separate these three main components from one another, and there are numerous possible approaches to the problem depending upon the purity required in the final product and the purpose to which it is to be put. For military plutonium it is necessary to decontaminate the plutonium product by a factor of 10^8, but it may well one day become acceptable to relax this factor to 10^2 for some power-reactor fuel cycles at present envisaged if the various consequent problems can be economically solved.[7] For example, the re-cycling of fuel from such a process would entail remote operation of mechanical refabrication devices, because the fuel would be contaminated by a number of different radioactive and toxic constituents.

Possible processes fall into the two main categories of aqueous and non-aqueous. It is with certain of the former with which this symposium was mainly concerned, but before proceeding with the detail reported there it is worth while to consider briefly the history of the chemical separation techniques.

The first method employed by the American project for the separation of plutonium for military purposes was the bismuth phosphate ($BiPO_4$) precipitation process. This process, in common with other aqueous systems, depends upon the fact that plutonium can exist in either of two (out of four possible) valency states, depending upon the degree of oxidation of the solution; that uranium behaves similarly, but is less easily reduced from the hexavalent to the tetravalent state so that valency differentiation between uranium and plutonium may be made; and also, but not common to all aqueous processes, that there are more water-soluble hexavalent salts of uranium and plutonium than of the tetravalent compounds. In this early process the plutonium, which existed in extremely low dilution in the process liquor (formed by dissolving the de-canned uranium metal in nitric acid), could be co-precipitated with bismuth as the phosphate, leaving most of the uranium and fission products in the liquid phase. The resultant solid precipitate, still highly radioactive besides being toxic on account of its plutonium content, must be centrifuged and re-dissolved in nitric acid, to be followed by further precipitations and dissolutions leading to a final precipitation using lanthanum fluoride (LaF_3). This process gave a very pure plutonium product, but entailed remotely-operated mechanical devices including the centrifuges, and also, as then operated, resulted in discarding the unused fertile uranium 238 (and the remaining uranium 235) along with the fission products. It also gave rise to large quantities of solid fission products requiring disposal, which are not easy to handle in a shielded process plant.

Solvent Extraction Processes

The phosphate precipitation process has now been entirely superseded by solvent extraction processes; and ion exchange processes have not been applied to primary separation because the high radiation levels from the fission products would damage the exchange resins. Solvent extraction processes themselves fall into two main classes. One system uses a specially selected organic complexing agent which forms a metal-organic complex which is highly soluble in an organic solvent. In the other system an organic substance is chosen which itself forms a complex with the metal salt to be extracted, the metal salt-organic solvent complex being itself soluble in the organic solvent, the partition between the aqueous and organic phases being governed by the presence

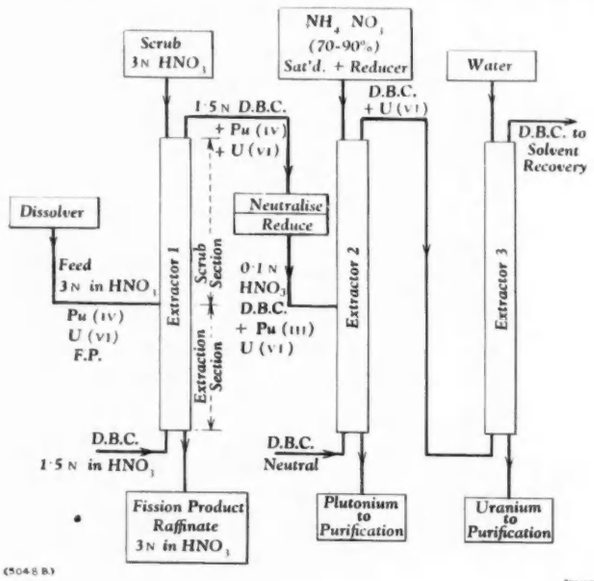
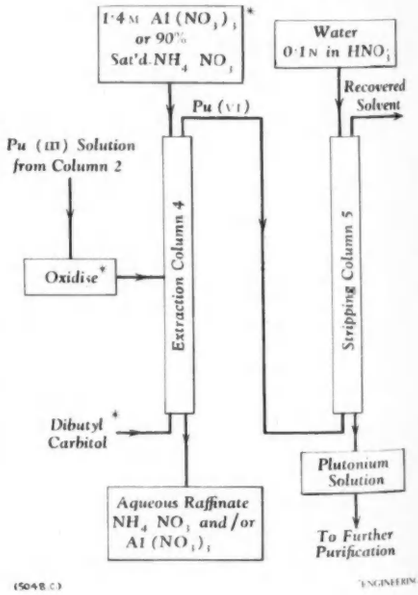


Fig. 2 (left) Outline of a preferred arrangement of the Butex process.

Fig. 3 (right) Second plutonium extraction cycle: columns 4 and 5 for plutonium recovery.

* The acidity would depend on the sorting-out agent used.



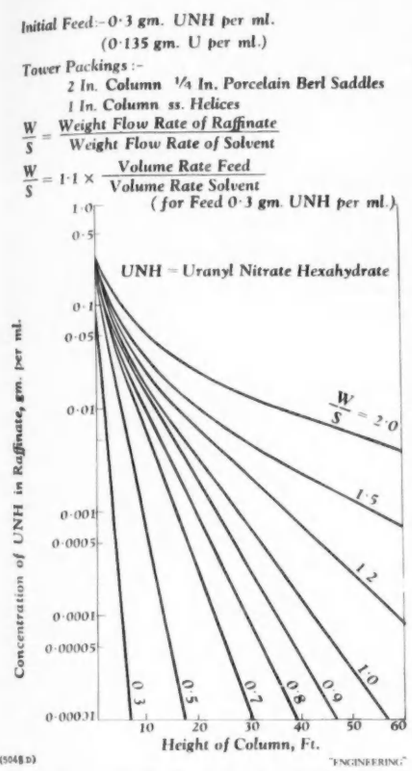


Fig. 4 Column heights required for extraction of uranium from aqueous solution 3·5 N in nitric acid (HNO_3) with dibutyl carbitol 1·8 N in nitric acid.
(1 in. and 2 in. diameter columns.)

of an inorganic "salting agent" which provides a concentration of the anion of the salt to be extracted to promote the formation of the complex at the expense of the aqueous solution of the metal cation. It is with the latter class of process that three of the symposium papers are concerned [1,5,6].

In all the solvent-extraction methods so far developed for the aqueous processes, either for plutonium extraction or uranium 235 recovery from enriched fuel elements, as before, the irradiated metal is dissolved in nitric acid to produce a solution which may or may not also contain a considerable quantity of aluminium or zirconium, depending upon whether the fuel is alloyed or not and upon the nature and method (if any) of bonding the sheathing material to the fuel material. Thereafter all the purification processes are carried out in the liquid phase until the final "dryway" stages leading directly to the production of the metal, in the case of uranium by first producing solid uranium oxide (by appropriate treatment of the final purified solution of uranium) which is then converted to uranium tetrafluoride (UF_4) by treatment with hydrogen fluoride (HF) gas, followed by magnesium reduction to metal.

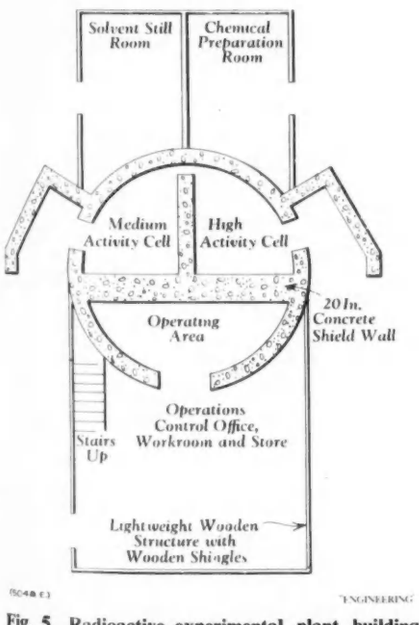


Fig. 5 Radioactive experimental plant building at Chalk River, Canada, for separation of plutonium from nuclear fuels—ground floor plan.

In the solvent extraction processes (see Fig. 1), the solvent is dispersed and caused to contact the aqueous phase by flowing counter-current in the process units, which may take the form of packed columns, pulsed columns or mixer-settlers. The original American "Redox" process was first operated in 1951 on a plant scale, and used methyl isobutyl ketone (hexone) as the solvent. This solvent was not, however, resistant to strong nitric acid and it was therefore necessary to use aluminium nitrate as a salting or stripping agent, the nitrate ion concentration which resulted causing the extractable nitrates to pass from the aqueous to the organic solvent phase. The presence of this dissolved salt in the fission-product raffinate stream limits the degree of concentration which may be achieved by evaporation while still keeping all the material in solution, which is a serious embarrassment in regard to fission product storage.

The "Redox" process was succeeded by the improved "Purex" process which used tributyl phosphate (abbreviation TBP, chemical formula $(C_4H_9)_3PO_4$) as the solvent. This solvent has the advantage that it is chemically stable in the presence of strong nitric acid, which may therefore be used as the strip feed with the double consequence that there is no salting agent in the form of a salt left in the fission product raffinate stream, and the nitric acid used to provide the salting ion may be recovered for re-use. Further advantages are that it is sufficiently stable to the fission-product gamma and beta radiations (which may amount to several hundred curies per litre); it has a very low mutual solubility with the aqueous phase; and it has a high selectivity for uranyl and plutonium (tetravalent) nitrates. A disadvantage of TBP is that it requires considerable dilution with odourless kerosine (OK) in order to provide a sufficient difference in density between the organic solvent and the aqueous solution for the efficient operation of the counter-current flow in a column, or the gravity-settling in a mixer-settler. This dilution reduces its extraction capacity, but this is more than off-set by its several other advantages. The process has been adopted for the British plant at Dounreay and the French plant at Marcoule[6] among others.

The Purex process, in common with the Butex process with which Mr. C. M. Nicholls' paper[1] is concerned, depends upon the following phenomena used in the proper succession and secured by suitable adjustment of chemical conditions. (1) Under strongly acid (oxidising) conditions both the uranium (or uranyl ion, from $UO_2(NO_3)_2$) and plutonium (in the tetravalent state) mainly from $Pu(NO_3)_4$ form an electrically neutral soluble complex with the solvent, which under the chosen conditions the bulk of the fission products do not, and may therefore be extracted together into the organic solvent from the aqueous solution of irradiated fuel. (2) Because of suitable density differences between the organic solvent and water and because these materials are mutually insoluble, the solvent and water solutions quickly separate after the mixing-contacting process, be this in a packed or pulsed counter-current contactor column or a mixer-settler unit. (3) By reducing the plutonium from the tetravalent ($Pu(NO_3)_4$) to the trivalent state ($Pu(NO_3)_3$) the same organic solvent may now be used to extract the uranium from the plutonium in a second stage of the process, since the partition coefficient (or relative solubility) of the trivalent plutonium in the solvent (that is its ability to form an organic complex) is reduced some thousandfold by the valency change, whereas that of the uranium is left unchanged in the hexavalent state (as $UO_2(NO_3)_2$), provided the reducing agent is chosen to be insufficiently strong also to reduce the uranium to the tetravalent condition. (4) Finally, the uranium can be re-extracted from the organic solvent into water due to the absence (or low concentration, in this case) of the salting agent (the nitrate ions) in the stripping feed solution.

These principles have been applied to a variety of different types of solvent-extraction plant, one of which is the British plutonium separation plant at Windscale. The very valuable paper by Dr. J. T. Wood and Mr. J. A. Williams[5] from which Fig. 1 is taken, deals in considerable detail with methods of calculating the dynamic performance of solvent extraction processes using equilibrium partition coefficient data, representative examples of which are given in the paper.

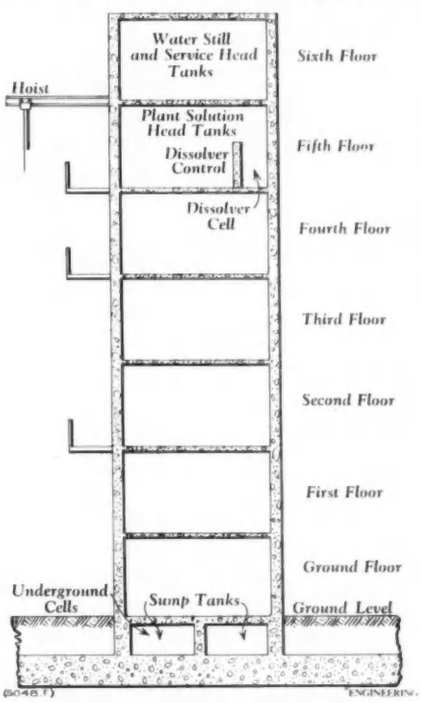


Fig. 6 Plant building—vertical section.

Butex Process Development

The paper by Mr. C. M. Nicholls[1] tells of the scientific and technical considerations which led to the construction and operation of a sizeable pilot plant, at the Chalk River establishment in Canada, in which could be carried out certain measurements essential for the design and operation of the full-scale long-life industrial-scale solvent-extraction plant eventually built in Britain. The selected process is shown diagrammatically in Fig. 2, and Fig. 3 illustrates the second plutonium extraction cycle. The starting point for the work described was in October, 1947. The following stage had been reached. (1) Some small-scale experience had been gained in the dissolution of uranium in nitric acid. (2) A continuous solvent extraction process was favoured with dibutyl carbitol (diethylene glycol dibutyl ether) as the first choice of solvent, hexone (methyl *iso*-butyl ketone) being the second choice. (3) Some insight had been obtained into the behaviour of uranium, plutonium, and fission products at equilibrium under a few selected conditions of extraction. (4) A few continuous runs had been carried out with uranium in small columns.

Points of special interest arising during the development work leading up to the construction of the radioactive pilot plant were: (i) the chosen process gave a fission-product stream practically free from dissolved salts and which was thus able to be concentrated by evaporation before storage, a matter of considerable economic significance; (ii) the size of solvent was unaffected by the type of feed distributor droplets employed after passing through 2 in. of packing (in a 2 in. diameter column) so the column feeds were made as simple straight inlet pipes feeding in just above the packing support; (iii) all the initial column

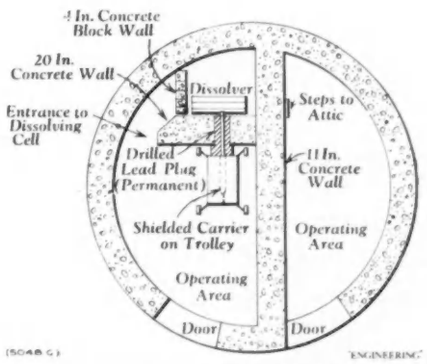


Fig. 7 Arrangement of plant for dissolving.

Continuing Atomic Review

extraction development work using plutonium and uranium together was carried out using only a small part of the then total available amount of plutonium of 20 milligrams; (iv) no work was done with actual fission products because of the practical difficulties of dealing with the radiation levels which would have resulted; (v) the use of ferrous sulphamate ($Fe(NH_2SO_3)_2$) to reduce the plutonium from the 4- to the 3-valent state was found to be so rapid in its action that the reduction could in fact all be effected in column 2 if desired, instead of during an intermediate stage. Table I and Fig. 4 indicate the effectiveness of the process in column 1 for extracting uranium from the aqueous nitrate solution.

TABLE I *Extraction of Uranium into Dibutyl Carbitol column 1—Dilute End of Extraction Section*

Aqueous phase acidity: 3·5N HNO_3
Solvent phase acidity: 1·8N HNO_3

Run No.	Flow ratio $\left(\frac{\text{Solvent}}{\text{Aqueous}}\right)$ (ml.)	Percentage extraction of uranium	$(H.T.U.)_{ow}$* (ft.)
27	0·45	53·5	11·0
32	0·565	65·3	7·3
31	0·82	82·7	4·35
29	1·10	90·6	4·2
30	1·49	98·2	2·1
28	2·05	99·6	1·5

* $(H.T.U.)_{ow}$ = the overall height of a transfer unit based on the change in concentration in the aqueous phase.

Table II shows the efficient manner in which column 1 also extracts the plutonium from the original solution along with the uranium. These experimental results were obtained using only trace quantities of plutonium. The separation of plutonium from uranium in column 2 was also shown to be highly effective, separation factors of between 100 and 500 being obtained, depending upon acidity.

TABLE II *Extraction of Pu^{IV} and Uranium column 1—Extraction Section, Dilute End Conditions*

Flow ratio $\left(\frac{\text{Solvent}}{\text{Aqueous}}\right)$ (ml.)	Percentage extraction	
	Uranium	Plutonium
0·53	65·2	93·1
0·91	89·4	97·8
1·45	98·8	100

Note: Roman numerals indicate valency state.

Radioactive Pilot Plant

The plant at Chalk River was the first continuous radioactive solvent extraction plant to be built and operated outside the United States. It was designed as a temporary installation upon the development data derived from the work described above, and was built in a 70 ft. high concrete tower, apparently some 20 ft. in diameter, and divided into seven floors. The only drawings of chemical plant which were prepared were layouts of major components. Pipework was installed by on-the-spot instructions, making much use of plastics (Saron) tubing in place of the welded stainless-steel pipework which would be used in a permanent industrial plant. Wooden-walled annexes attached to the tower served for control-room, work-room, radiation-proof chemical preparation rooms, etc. The rooms inside the tower were partitioned into radiation-proof cells as required by the provision of concrete partition walls, as indicated in Figs. 5, 6 and 7. Much practical operating experience, including the cleaning-up of a fair-sized radioactive spill, will be obtained from this plant besides design data for the production plant. The best performances obtained, as indicated from about 10,000 analyses, are given in Table III.

TABLE III *Extraction Results*

Uranium stream from Column 3: (Columns 1, 2 and 3 overall separations.)	
Uranium recovery	95·4 per cent. (> 99·9 per cent. possible.)
*Decontamination from $\beta + \gamma$ emitters	U $DF_{\beta\gamma} = 5 \times 10^2$
*Decontamination from plutonium	U $DF_{Pu} = 3 \times 10^2$ (This could be considerably improved by selecting the best combination of column 2 length and solution flow rates.)
Plutonium stream from Column 5: (Columns 1, 2, 4 and 5 overall separations.)	
Plutonium recovery	98·8 per cent. (> 99·9 per cent. possible.)
*Decontamination from $\beta + \gamma$ emitters	Pu $DF_{\beta\gamma} = 3 \times 10^3$
*Decontamination from uranium	Pu $DF_U = 4{\cdot}5 \times 10^2$ (Practically complete elimination of uranium is possible. Pu $DF_U = 2 \times 10^4$ was achieved under special conditions.)

* The decontamination factor (DF) for a given element is defined as the ratio of the concentration of that element in the stream entering to that leaving the equipment or plant, e.g., U $DF_{\beta\gamma}$, the measure of the elimination of β and γ emitters from the uranium, is given by:

$$\text{U } DF_{\beta\gamma} = \left[\frac{\text{Concentration of } \beta \text{ and } \gamma \text{ emitters in inlet stream}}{\text{Concentration of uranium in inlet stream}}\right] \div \left[\frac{\text{Concentration of } \beta \text{ and } \gamma \text{ emitters in exit stream}}{\text{Concentration of uranium in exit stream}}\right]$$

A further oxidation, extraction, and stripping cycle on the column 5 product, increased Pu $DF_{\beta\gamma}$ to 9×10^4 and Pu DF_U to 2×10^4. (The highest value achieved for this last factor was 10^6.)

Outcome

The Windscale plant was based upon this work by Mr. Nicholls and his colleagues. An important complementary part of the work both concurrent with and following the pilot plant experiment was the scaling-up of the process in which an important part was played by the I.C.I. team in Britain using only natural uranium, at Springfields. Yet further development will no doubt be needed to provide economic and suitable capacity for the five tonnes of plutonium production per year forecast by Dankwerts for mid-1960 in the discussion following the papers, and perhaps Mr. Nicholls' forecast in another discussion,[7] that pulsed columns or mixer-settlers would be used in future plants rather than simple packed columns should be noted.

REFERENCES

(The first six references refer to the B.N.E.C. symposium.)

[1] C. M. Nicholls, "The Development of the Butex Process for the Industrial Separation of Plutonium from Nuclear Reactor Fuels."
[2] K. Saddington, "Fission Product Disposal."
[3] C. M. Nicholls and A. H. C. P. Gillieson, "Nuclear Criticality —A Novel Factor in the Design and Operation of Chemical Plants."
[4] I. Wells and E. Lofthouse, "Fuel Processing in Homogeneous Aqueous Reactors."
[5] J. T. Wood and J. A. Williams, "Computation of the Performance of a Multicomponent Solvent Extraction System. The Separation of Uranium and Plutonium from Fission Products by Tributyl Phosphate."
[6] R. Galley, "The Marcoule Plutonium Plant."
[7] C. M. Nicholls and R. Spence, "Chemical Processing of Nuclear Fuels," *B.N.E.C. Journal*, Vol. 2, No. 2, October (1957). Also "Atomic Review," ENGINEERING, p. 793, March 8 (1957).

(This summary of the B.N.E.C. symposium will be completed in a subsequent Atomic Review.)

Notes and News

Eurochemic

The founders of Eurochemic, the European company for the chemical processing of irradiated fuels, have held their first meeting at the headquarters of the O.E.E.C. The company was set up in Paris on December 20 by 12 member countries of the Organisation, and was discussed in Atomic Review last January 17. The chairman of the meeting was Dr. Erich Pohland, of the Federal German Ministry of Atomic Affairs, and the vice-chairman Dr. Erik Svenke, Head of the Industrial Division of the Swedish atomic energy corporation. The purpose of the meeting was to take the necessary steps to start forthwith the preparatory work for the construction of the plant and laboratories which the company will operate near the nuclear centre at Mol (Belgium). It was decided—in agreement with the Belgian Centre for Nuclear Studies, represented by its Director General, Monsieur Louis de Heem—that a first team of specialists to prepare the final plans of the plant and to start the preliminary research would start work immediately at the premises of the Mol Centre, which are to be placed at the company's disposal during the initial period.

European Nuclear Energy Agency

The European Nuclear Energy Agency was formally established on February 2. Britain is a member of the agency. Mr. R. A. Butler, speaking in the House, drew attention to the link this membership provided through O.E.E.C. with Euratom.

Industrial Conference on Reactor Progress

The United Kingdom Atomic Energy Authority announce that they are to hold a Conference at Harwell on June 11, 1958, at which recent developments in nuclear reactor technology will be discussed with representatives of British industry. Accommodation will be available for about two hundred representatives from industry. Because of the limited accommodation available it will probably be necessary to restrict the number of representatives from each firm. Requests for further details and for reservations should be made to the Director (Industrial Liaison Office), Building 329, Atomic Energy Research Establishment, Harwell, Near Didcot, Berkshire, not later than March 15, 1958. The first conference with British industry on the Authority's programme of research on advanced types of nuclear power reactor systems was held in November, 1956. The conference now announced will inform industry of the progress achieved over the last eighteen months.

Dounreay Reactor Ready Soon

Answering a question put to the Prime Minister recently, Mr. R. A. Butler, the Home Secretary, told the Commons that the construction of the fast breeder reactor at Dounreay was now almost completed, but that there would be a period of several months during which tests would be carried out with equipment and controls before the reactor was brought into use.

U.K.A.E.A. Appointments

A number of new appointments have been made by the United Kingdom Atomic Energy Authority. Mr. J. C. C. Stewart, formerly Director of Technical Policy in the Industrial Group at Risley, becomes a Deputy Managing Director of the Industrial Group. Mr. J. B. W. Cunningham, formerly Deputy Director (Civil Reactors), becomes Director of Industrial Power in the Industrial Group. Dr. R. Hurst, formerly Chief Chemist in the Research and Development Branch of the Industrial Group at Risley, becomes Director of the Dounreay Experimental Reactor Establishment. Mr. D. S. Mitchell, formerly Director of Administration, becomes Director of Personnel and Administration in the Industrial Group. All these appointments, which took effect on February 1, 1958, mark a first stage towards implementing recommendations made by the committee appointed by the Prime Minister under the chairmanship of Sir Alexander Fleck to examine the organisation of certain parts of the Authority. Further appointments will be announced in due course. Mr. D. W. Fry, Chief Physicist at Harwell, has been appointed a Deputy Director of the Atomic Energy Research Establishment and will take up his new post on February 17, 1958.

Calder Operation School

The Calder Operation School recently completed its first year. The first students reported on January 28, 1957, and since then four further courses have been run. A sixth commenced on January 6, this year. The course lasts for six weeks and is designed to give students an outline of the design, construction, commissioning (see Atomic Review last week) and operation of the Calder reactors.

Induction Heater and Neutron Counters for Zeta

A standard 3½ kW Radyne C.21 induction heater has been modified to provide a radio-frequency discharge for ionising the gas in the main toroidal tube of Zeta. By making the gas conductive it forms a short-circuited secondary coil, the primary of which is the main winding around the toroidal tube. The heater was primarily designed for industrial purposes of a varied nature, namely heat treatment, electronic vacuum work, soldering and brazing on the production line. The C.21 heater is made by Radio Heaters Limited, Eastheath-avenue, Wokingham, Berkshire.

A fast neutron counter made by Solus Electronic Tubes Limited, is among the equipment used in conjunction with Zeta. The tube, which is one of the company's TV701 FN2/12 models, is used to measure biological hazard, and is installed in the control room.

Companies in the News

Back in Top Gear

The latest results of the David Brown Corporation Limited suggest that last year's slump in profits was a temporary domestic affair. Their chairman, Mr. David Brown, was able to tell shareholders, " with some pleasure " that profits before tax were up to £469,240 from £24,108. Their year ends at June 30, and little happened in that period which could produce so heartening a recovery except a good spring clean in the group's affairs. The liquid position has been considerably improved. Indebtedness was reduced by over £350,000 during the year, and Bank overdrafts by £766,000, much of it being realised from a reduction of stocks and work in progress to well under £1 million.

Mr. Brown made it clear that the improved liquidity was not due to skimping on plant renewal and modernisation. Over £½ million was spent on capital account. The commercial performance has been good. The gear and foundry divisions have worked throughout the year " at a high level of productivity " and have a full year's work on their books. The automotive division has sold a year's output ahead and the tractor division, " as a result of the introduction of its new 900-series machines," has considerably strengthened its position and has " a substantial back-log of orders." Machine tools and small tools are selling well—orders for large machines have been received " in the face of American and German competition " and the Hydrax range introduced two years ago is selling " in increasing numbers." There is good news too from overseas companies, in South Africa—" output increased by 20 per cent.," and in Canada—operated at a profit " for the first time since its inception."

The chairman was cautious in his interpretation of prospects, but quite confident that the current year's results would reflect " a further step forward " towards regaining the former level of profitability. The introduction of new products, in the agricultural machinery field as well as in nuclear engineering, indicate that the company are keenly aware of the need to change with the times.

On the whole therefore there is enough evidence to conclude that the group have got back into top gear and will continue to improve their position.

Invasion from Outside

A new force has entered the engineering field designed to absorb the investment of substantial reserves accumulated in another. The Booker Brothers McConnell group of companies, prominent for over a century in the West Indian sugar trade, recently formed Bookers Engineering Holdings for this purpose. They have just announced their purchase of Duncan Stewart and Company, of Glasgow, which comprises the sugar machinery business of the Davy-United group. " Duncan Stewart will continue to operate, with independent responsibility, under the present administrative, technical, and sales staff in charge of sugar machinery in Glasgow; but from new offices at Stewart House, Park Gate. The ownership of the works and premises at Summer Street, has been transferred to Davy and United and these will continue to operate as part of the Davy-United Group. Arrangements have been made, however, whereby manufacturing facilities for certain plant will continue to be available for Duncan Stewart at the Glasgow and Sheffield works of Davy and United."

Bookers are known to be interested in other engineering companies, which for one reason or another, need finance to develop successfully the full potential of their products. This kind of interest, which seeks above all an investment in expanding markets and is prepared to finance expansion and long-term development, is very much needed in engineering. Many firms whose growth is mainly post-war have found the successive attempts by the Government to arrest the wave of inflation (on which they were carried) a little too much to bear. Over trading, or—in the case of many companies with good technical direction—over spending on research and development is having its inevitable aftermath. It is a painful and familiar story and Bookers—whose task in assessing the genuine prospect from the badly managed must be a difficult one—have a useful and constructive part to play.

Timely Diversification

The slowing down and cancellation of military orders has created a major problem of adaptation for suppliers to aircraft firms. The Government have been taking up some 60 per cent. of the industry's capacity and the switch to guided-weapon strategy has led to a surplus of most components. Even if the industry is highly successful in the export market for passenger and transport aircraft some considerable contraction will have to take place. The tragedy of the situation is that very few among manufacturers of components took appropriate action in good time. The chairman of Associated Engineering Holdings Limited, Mr. Henry R. Moore, told his company's shareholders last week that " considerable thought " was being given to plans for extending the group's activities into new fields in which their existing skills in high precision quantity production could be " allied to new products of a proprietary nature."

The A.E.H. group specialise in the production of light alloy products, including aluminium alloy forgings and castings for aircraft, and are the leading makers of pistons and piston rings for road vehicles. The introduction of new products, particularly of products with wide industrial applications, is a slow business and, as Mr. Moore points out, is unlikely to exercise " any material effect on the group's earning capacity " for some considerable time.

This sudden switch of highly skilled manufacturing capacity to other fields should be highly beneficial to the engineering industry. Much of it must necessarily go into completely new products with a high skill content, and it is on this type of activity that the country will increasingly depend for its exports. It is unfortunate that powerful firms such as A.E.H.—and most of their competitors—should have waited so long before adopting a dynamic policy of diversification. Those who have done this when the war ended—the Dowty Group is a good example—are now in a very strong position as industrial suppliers. There is plenty of room still for the switch of new capacity but the difficulty of getting finance, and the increasing competition for foreign manufacturing licenses, make the task much more difficult now than it was 10 years ago.

Mixed Feeling in Contracting

Various statements and announcements of contracts by civil engineering companies suggest that the slack period most of the industry experienced during the past few months may be short-lived, at any rate for the larger organisations. Recently there was the announcement that John Laing had been given a £15 million contract for road building. Last week Matthew Hall were awarded a contract for the design, procurement, construction and commissioning of the new chemicals buildings at the Warrington factory of Joseph Crossfields and Sons Limited. This covers a new chemical plant for the manufacture of industrial detergents, silica gels and other chemicals, which is due to be completed in July, 1959. Matthew Hall's contract is worth approximately £1 million.

The annual statement of the chairman of Hawkins Bros. Holdings (Gosport) shows that appalling weather rather than shortage of orders affected operations during the year ended at September 30. Their chairman, Mr. Warwick Martin, took an optimistic view of the future. " Despite keen competition for all classes of buildings and civil engineering projects," he said that the company have an order book of over £1 million and that their estimating department was " still fully occupied in preparing estimates for further projects." Most civil engineering firms are similarly placed and are likely to be fully employed during the current year. Nonetheless, there has been a disturbing fall in the amount of factory work being approved and it will take many large projects to offset this. Fewer houses, too, are being built.

The comment of Mr. John Wooler, chairman of William Briggs and Sons Limited, summarises very well the position and outlook of the more progressive companies in the industry: " I feel satisfied that, although the present signs suggest that trading will be more difficult during the current year than it has been in recent times, we can face the future with confidence in the knowledge that we have a strong, well-knit, adaptable organisation, with up-to-date plant and adequate financial resources." The last two will be the key to success in the next few months.

Hard Times for Compressors

The year ended at September 30 has been a difficult one for the manufacturers of compressors, except in the marine market. Mr. Harry S. Broom, chairman of Broom and Wade Limited, told shareholders that (apart from the Suez crisis), "high taxation, the credit squeeze and the increased Bank Rate have resulted in a reduction in the demand for capital goods and in civil engineering contracts." Mr. Broom takes a gloomy view also of demand in export markets where import restrictions and increased competition have made selling " more difficult." But Broom and Wade, like most of their competitors during the past few months, have made a great effort to streamline their sales methods, strengthen sales staff and increase advertising. Despite this, trading profits declined by 9 per cent. to £566,000. Nonetheless, some benefit from the increased sales drive is evidently being felt, since Mr. Broom concludes by saying that the company's order book is " in a healthy state " and that their expectations of business and profits are not below the level " consistent with past years."

One of the reasons for this confidence in the face of seemingly deteriorating conditions is the faith the company have in their product development policy. The new oil-flooded rotary compressor they have produced is " proving its worth " and being further improved. Mr. Broom described it as " one of the greatest advances in the history of compressed air " and said it had been very well received. Although Broom and Wade continue to make the sleeve-valve type of portable compressor they expect the rotary machine to displace it in due course because it is a more efficient product, relatively light and employs high-speed engines.

This is an interesting example of commercial strength through technical advance. Mr. Broom said that only one other firm in Europe is producing a similar compressor, " to drawings supplied from America." Another example of enterprise in the compressor field is the setting up of a manufacturing unit in India (at Muland, near Bombay) by Consolidated Pneumatic Tool Company. This will be the first full scale production unit in India to specialise in this field and will be operated entirely by Indian labour (about 400 when in full production), and Indian technicians are now being trained at the company's factory in Fraserburgh. The managing director will be an Indian and the whole enterprise will thus be a fully co-operative effort financed by British capital and sustained by British experience and technical skill.

In Parliament

POWER PROBLEMS

Lord Macdonald of Gwaenysgor (Labour) opened an interesting "whole-day" debate in the House of Lords last week on the development and use of the fuel and power resources of the United Kingdom, and on the need for closer co-ordination between the responsible authorities.

He expressed himself as being satisfied that the level of the pound sterling would depend very much on the activities of the authorities concerned in these matters, especially the National Coal Board, the Gas Council, the Electricity Authority, and the United Kingdom Atomic Energy Authority. He would exclude, however, the private sector of industry.

The nationalisation of the coal industry had come to stay but those who had given forty or fifty years to establishing nationalisation sometimes had pangs of disappointment, as it had not achieved all that had been expected. More coal could be produced and what was produced could be used to better advantage.

Absenteeism among miners was to be regretted and voluntary absenteeism could never be justified except in extraordinary circumstances. The miners' leaders were as anxious about the problem as anyone else and were doing the best they could to reduce it. In Lancashire, some of these leaders had decided to institute among themselves, along with the National Coal Board, a disciplinary body. In general, some method would have to be found of instilling that sense of responsibility which was lacking in a small percentage of the miners. Tremendous patience was needed and a mistaken policy could do disastrous harm.

How much was the Government doing—it could not do everything—to secure the more efficient use of coal, both on the domestic hearth and in factories and engineering workshops? In his opinion, any attempt to secure the more rational use of coal so as to avoid waste and limit the nation's dependence on imported oil would cause an industrial storm. From his industrial experience, did the Minister of Power favour a national fuel policy? If he did, had he behind him the necessary scientific advice to enable him to set up the type of body which would control national fuel policy?

NUCLEAR ACHIEVEMENTS

So far as technical efficiency was concerned, Viscount Stonehaven (Conservative), who spoke next, considered that no one could criticise the nationalised industries on the grounds of technical efficiency. The electricity authorities, for instance, were running at an efficiency of almost 90 per cent. and were burning what could only be described as the most utter muck to do it.

The power to be derived from Zeta and other forms of atomic energy was not going to affect the importance of coal until well into the middle of next century. It was often cheaper to save a ton of coal than to mine one. He wondered whether installations burning 500 tons of coal a year—installations down to that size—were sufficiently well instrumented. It was surely desirable that any stoker in charge of a hand-firing plant should have a City and Guilds certificate of competence.

Lord Teviot (National Liberal) felt that if Britain were to get the best out of this important industry, she must give up buying coal which could be produced here, provided that the necessary labour were available. That raised the problem, he said, of the employment of foreign miners.

Zeta, it was pointed out by Viscount Hall (Labour), provided the means of obtaining power for industry and many other purposes from an entirely new source of fuel. It could rightly be claimed that the United Kingdom now had in operation the two largest experimental machines in the world for that purpose, namely, the Atomic Energy Authority's Zeta and the Associated Electrical Industries' Sceptre III. It was to be hoped this great British achievement did not go the way of so many scientific discoveries in which Britain had been the first in research, but well behind in application. He understood that expenditure in this field during the past few years had averaged about £2 million a year, compared with an expenditure by the United States of many times that amount.

Replying to the debate on behalf of the Government, Lord Mills, the Minister of Power, said that Britain was probably reaching the turning point in the field of fuel and power. Since 1948, the consumption of coal had increased by 10 per cent., but the consumption of oil had gone up by 91 per cent. Coke consumption had risen by 15 per cent., gas by 27 per cent., and electricity by 99 per cent. Whereas before the war these refined products accounted for only a quarter of inland fuel consumption, they now accounted for 40 per cent. or more. Taking all fuels together, 60 per cent. was used by industry and commerce, 27 per cent. by domestic consumers and 13 per cent. by transport.

It had taken 18 years to produce Calder Hall: the prototype on which this country's nuclear power programme was based. The highest possible priority would be given to following up Zeta achievements, but it was a road that would have to be followed step by step. (Reference to a statement by Lord Mills on Britain's power resources is made in Weekly Survey on page 194 of this issue.)

RUSSIAN SCIENTIFIC LITERATURE

In a statement on behalf of the Lord President of the Council, whose representative he is in the Commons, Mr. Harmar Nicholls, the Parliamentary Secretary to the Ministry of Works, said that the Lending Library Unit of the Department of Scientific and Industrial Research was actively building up what was already a considerable collection of Russian scientific and technical books and periodicals. In order to make the existence of this literature as widely known as possible, the Department was informing all organisations in the United Kingdom concerned with scientific abstracts about the material which it was receiving. The Department was also making special arrangements, when re-requested to do so, to lend Russian material to abstracting organisations.

As previously explained to the House, Mr. Nicholls told Mr. F. T. Willey (Labour), the Department already had in being a small co-operative translation scheme, under which the cost of a translation of a Russian scientific paper was shared by the persons interested. Ways and means of extending the arrangements for translation were being considered, but the large-scale translation of Russian scientific literature must inevitably be expensive.

TECHNICAL TRAINING GRANTS

Local authority associations had agreed with him, Mr. Geoffrey Lloyd, the Minister of Education, told the House, that new scales of grants should be established from the beginning of the 1958-59 session for students who enter the one-year courses of pre-service training at technical training colleges. The full details of these scales could not be settled before the completion of the triennial review of the standard figures of maintenance for students at universities and of training college grants, which was now in progress. All students eligible for assistance, however, would receive increased personal grants, with increases in the grants to their dependants and a special grant for persons who had to maintain a separate home while in training.

There was general agreement, he told Mr. Isaac Pitman (Conservative), with the views of Dr. Willis Jackson's Committee on the Supply and Training of Technical Teachers that a student who was receiving a grant at one of these colleges, and who was a married man with one or more children and a separate home to maintain, should be no worse off financially than if he were earning the basic minimum salary on the scale for grade A assistants in technical colleges (at present £475).

Courses would also be arranged for teachers already in service in the technical colleges and further discussions were proceeding regarding the arrangements to be made for that purpose.

Alkali Inspectorate Districts

Answering a question by Mr. David Jones (Labour) regarding the number of districts in the Alkali Inspectorate, Mr. J. R. Bevins, the Parliamentary Secretary to the Ministry of Housing and Local Government, said that there were at present ten, including one inspector employed on special duties. There were seven districts in England and Wales, but the number would be increased when the Inspectorate was increased. The "districts" were based on industries and not on administrative areas.

£35 Free Coal per Annum

Sir Ian Horobin, Parliamentary Secretary to the Ministry of Power, told Brigadier Terence Clarke (Conservative) that miners are entitled to free or concessionary coal worth, on an average, £35 a year.

Welsh Tin-Plate Works Close

Sir Ian Horobin told Mr. David Williams (Labour) that ten old-type tin-plate works and two steelworks in west South Wales had been closed permanently since January 1, 1957. One tin-plate works, four sheet-metal works and one steelworks had also been closed on a temporary basis. A further steelworks was under notice to close.

Servicing Military Aircraft

Private industry executed all major repair work on Royal Air Force aircraft and equipment, and about 30 per cent. of field repairs in this country, Mr. George Ward, the Secretary of State for Air, told Mr. Austen Albu (Labour). The remaining field repairs of aircraft, and virtually all servicing of aircraft and equipment, were carried out by R.A.F. units. The amount of aircraft equipment manufactured in such units was negligible.

Value of Work Study Methods

Much importance was attached by his Department, Mr. Iain Macleod, the Minister of Labour, told Mr. J. W. W. Peyton (Conservative) regarding the application of work study in industrial undertakings of all kinds. Indeed, firms were encouraged by other Government Departments, as well as by the Ministry of Labour, to make full use of these methods, in promoting which the British Productivity Council was also engaged.

Unemployed Welsh Tradesmen

Information was not readily available, Mr. Macleod said, respecting the number of craftsmen in Wales who had been registered as unemployed over the past three months. On December 9 last, he told Mr. George Thomas (Labour), 241 men were wholly unemployed in the principal engineering and shipbuilding occupations there, as compared with 228 in September.

Financing Nationalised Industries

Replying to a question by Colonel C. G. Lancaster (Conservative) as to the provision being made for meeting the capital requirements of the nationalised industries after March 31, when the powers to make exchequer advances expire, Mr. Reginald Maudling, the Paymaster-General, said that the Government would be introducing a Bill very shortly. The Bill would permit the present powers to be exercised until the end of August, but only within the limit of the money already authorised. That arrangement would give time to consider the future of this method of financing these industries in the context of the Government's general policies, and to include any provisions that might be necessary in the Finance Bill.

Marketing

PRICES UNDER FIRE

News about price changes is coming in faster each week, and the accent is unmistakably on cuts. The most spectacular reductions achieved recently were those by Marks and Spencer, the retail chain store. They commenced a " new lower price campaign " as their contribution in the fight against inflation in support of the Government's efforts in that direction. The remarkable feature about the Marks and Spencer price cuts is that they were achieved deliberately, methodically, by the revision of all costs of distribution, resulting in startling simplifications in method. Paper work was slashed to levels which would doubtless alarm the average firm, clocking-in eliminated, stock keepers swept away and everything reduced to the most simple pattern of organisation possible. The results were reductions in prices from 5 to 19 per cent. over a wide range of products including cakes and confectionery, children's knitwear and men's apparel.

The Government themselves are getting into gear with their own price-reduction campaign. In their latest *Bulletin for Industry* the Treasury state that in 1958 the country has an excellent opportunity to achieve " a decisive victory over inflation." They mention the extensive falls in commodity prices, which had by December brought the average prices of basic raw materials some 10 per cent. below the level reached in April, and say there is now scope for a fall in the prices of manufactures. Another argument used by the Treasury is the vast increase in manufacturing capacity that has taken place over the past two years and is now coming into production: " this still unrealised prospect for increased production, together with the recent fall in import costs, gives an opportunity for price reductions this year, provided there is restraint in seeking higher incomes and, therefore, some stability in home costs." Certainly there is no argument so effective in appeals for wage restraint as falling household goods prices.

Quite apart from the Government's wish to see prices reduced, there is building up a strong pressure in the same direction from economic factors. At a recent meeting of the Council of the Association of Engineering Distributors, Mr. R. F. Hatto, sales director of Wolf Electric Tools Limited, spoke strongly against price cutting by distributors. Nothing is as easy as to make cuts, he argued, but conversely nothing is so hard as to get them back after they have once been made. He showed what the familiar argument " lower prices mean a higher volume of sales," means in practical terms; if a merchant is working on a 25 per cent. margin he requires a 25 per cent. increase in volume to compensate for a 5 per cent. cut in price and one of 150 per cent. in volume for a 15 per cent. cut in price. He hoped that members of the A.E.D. would " analyse the reasons for price cutting and perhaps work out a solution." In the United States the current business slump has produced what *Business Week* describes as a " spreading story of discounts, concessions, and salesmen's 'errors'." For machinery, machine tools, transformers, some chemicals and some fuels, prices are now 5 to 10 per cent. below the level of a year ago. Heavy machinery suppliers are quoting delivered prices as much as 20 per cent. lower, the concessions taking the form of " absorbed freight charges, cancelled premium prices and higher discounts for smaller shipments." Buyers believe this is only a beginning—in the words of a big Milwaukee machinery buyer " we've hardly had a taste of what will happen if business gets slower."

In this country few price reductions have yet been announced in respect of engineering products. The British Central Electrical Company reduced their price for a full-load earth continuity tester from £20 to £17 10*s*. and De La Rue announced price cuts ranging from 5 to 13 per cent. for their oil-fired boilers. Competition and falling order books may yet prove the Government's most effective support in their price-reduction campaign.

Salesmanship

A two-day course, " The Art of Selling," aimed at salesmen and sales managers, is being organised by the British Institute of Management at Caxton Hall, London, on March 13-14. It will be conducted by Mr. Heinz M. Goldmann, a consultant in sales training with offices in Geneva, Stockholm and Germany. In their announcement the B.I.M. describe this as an opportunity for businessmen to prepare " for the competitive atmosphere of the European common market and free trade area."

Mr. Goldmann has considerable experience in training salesmen. He has already conducted courses for more than 40,000 of them, from 4,000 companies in 11 countries, including the United States and Canada. He knows European methods and his own, " based on analysis of customer reactions," is said to be applicable to all types of selling. Selling, says Mr. Goldmann, really begins when the customer says " no " and consists in overcoming resistances—eight of them, which he illustrates in a film. A mixture of " sales psychology," " sales arguments," and hints on " handling difficult customers " should make for an interesting two days.

Television Train

The Scottish Region of British Railways lacks neither in patriotism nor in initiative and sales consciousness. The television train that they have been running for pleasure excursions will shortly become a travelling exhibition of Scottish manufactures. Three coaches will be added, each specially fitted to display a range of knitwear, sportswear, textiles and fashions made in Scotland for the coming spring season. Closed-circuit television will be used to portray technical details and new designs to invited audiences.

The growing use of mobile showrooms—hitherto mainly caravans and ships—in this case with the powerful support of television, threatens to revolutionise selling and advertising methods. Already many engineering firms have adopted the caravan showroom approach with encouraging results. Whether they will adopt television (other than closed circuit) as a medium for their advertising is more doubtful. Expenditure last year on television advertising of engineering products was largely confined to cars, cycles and motor cycles and household appliances, but the amount spent was relatively very small and less than in 1956, although total spending on I.T.V. rose from £13·7 million in that year to £32 million in 1957. One reason put forward is that the impact of television does not last as long as other forms of advertising and is therefore most suitable for low-cost products likely to be bought the next day. So far the technical Press remains unchallenged as the principal medium for engineering products.

Canadian Follow Up

Several British engineering firms are moving into Canada to back up the efforts made recently by Canadian and British missions to promote trade between the two countries. Larmuth and Bulmer, the manufacturers of wire and cable-making machines, sent their technical director, Mr. F. M. Larmuth, to visit each industrial province of Canada. One of the purposes of the visit is to provide information on " an improved spares service for users of Larmuth machines."

W. H. Dorman and Company, manufacturers of Diesel engines, and Pollard Bearings, who specialise in self-lubricating bearing units, have both sent directors and senior sales officials to Canada. Mr. J. W. Whimpenny, joint managing director, and Mr. I. MacLeod-Smith, general sales manager, will visit Dorman's subsidiary in Toronto and all their agents. Mr. John L. King, managing director of Pollard Bearings and Mr. J. H. D. Price, their sales manager, go there to visit the company's new factory at Oakville, Toronto, to arrange distributor contracts.

Two of these companies have manufacturing units in Canada; there is little evidence so far of a determined effort on the part of would-be new entrants to the market. Clearly this is what was hoped for by the Canadians when their large mission came here. Mr. Diefenbaker's decision to go to the country for a more clear-cut mandate could, if successful, be a tremendous uplift to British exporters.

Progress at Brussels

Excellent progress is being made on the building of the British section at the Universal and International Exhibition to be held at Brussels from April 17 to October 19 this year. Richard Costain Limited, who are the main contractors for the whole of the British side, have completed the structural work on the Government Pavilion and the British Industry Pavilion where the finishing trades are now busy.

The Federation of British Industries, who are organising British representation in the Industry Pavilion through their subsidiary, British Overseas Fairs Limited, recently held a Press conference to give information on the participation of the engineering industries at the Fair. These industries will be represented by seven organisations, including five manufacturing companies—Acrow Engineers, British Timken, Clarke Chapman, Renold Chains, and Rolls-Royce. The Agricultural Engineers Association will exhibit on behalf of their members and the Birmingham Exchange and Engineering Centre will represent the light and medium industries, displaying the products of some 85 firms.

Engineering items now account for almost 40 per cent. of all British exports compared with about 25 per cent. before the war, but it is impossible to find space for all firms wishing to take part. The F.B.I. are confident, however, that the exhibits selected will give " a good impression both of the diversity of British engineering and of the export potentialities of the industry."

Market Place in New York City

The management of the 1958 United States World Trade Fair to be held in May have published an independent survey of a broad cross-section of industry in the Western Hemisphere. Attendance of buyers is forecast at " substantially above " the 127,780 who attended last year's Fair, and the number of visitors may exceed 1 million during the 10 days.

One of the striking features of this Fair is the manner in which it is being promoted and advertised, with considerable gusto and drive. One of the more interesting points quoted from the survey is that small manufacturers find the Fair a " boon " because they are " unable to have their men cover foreign markets on a sufficiently broad and consistent scale." This does not seem to apply in this country (except possibly to buyers) when small firms tend to sell locally and shun the relatively heavy expense of a distant exhibition. It certainly does not apply to engineering firms who must have a full coverage whenever they sell in order to service their products. On the whole, the promoters of the New York Fair probably overstate their case but there is little doubt that a British firm with an existing stake in North America has little option but to follow suit and book space.

Management

WAGES AND PRODUCTION

What determines the level of wages? Is it possible to link wages and production in such a way that real wages rise in step with output? Again, is it enough to leave wage negotiations to be decided in favour of whichever side happens to be able to bang loudest on the table at a given moment? These were two of the questions dealt with at a recent conference organised by the Institute of Personnel Management, and held at Harrogate towards the end of last year.

1. No Slide Rule for Wages

An interesting analysis of the urgent problem of fitting the growth of personal incomes to the rise of industrial output was made by Sir Richard Snedden at the conference of the Institute of Personnel Management. The classic approach to wages is that each industry should give the best wages it could afford in order to attract the best labour. Ability to pay is the determining factor in wage levels, but there is no simple formula for linking wage levels and production.

There are seven reasons why such a magic formula is unlikely to be discovered. First, the Trades Union Congress and the British Employers' Confederation would have to reach an agreement that would be binding on their members. Neither has the power to do this. Second, the general index of production, the usual measuring rod for production increases, is far from comprehensive and in fact only covers half the employed population. Third, any index of production has limitations if only because the number of products capable of unambiguous measurement and comparison at different dates is relatively small. Fourth, labour is not the only claimant to a share in increased production. The consumer has a claim and so has capital. Fifth, actual increases in production vary from industry to industry, firm to firm, department to department and even worker to worker. It is not easy to persuade those who only know the results of their own efforts to share the benefits with others. Sixth, " fringe " benefits must not be left out in considering wages. Reduced hours, increased pensions and longer holidays can be just as inflationary as direct wage increases. Seventh, when anything is scarce its price rises. This is equally true of labour. It is the shortage of labour that makes employers grant wage increases and sometimes compels trade union leaders to put forward wage claims that they know may not be in the best long-term interests of their own members.

2. A Wages Policy

A frequently advocated way out of the problem of fitting wages to production is the demand for a strong type of unified, planned wages policy to replace the traditional patterns of bargaining. The demand for a wages policy was discussed by Professor D. T. Jack at the Institute of Personnel Management conference. The advantages of the traditional methods of wage negotiation are flexibility and the fostering of a sense of responsibility on the part of the negotiating parties. There are three main sources from which demand for a different type of system comes. The first is the widespread recognition that in a period of inflation the wage-price spiral is frustrating to all wage earners alike. Secondly, in a period of full-employment, bargaining strength is heavily weighted on the side of the unions, so that wage increases almost inevitably outstrip rises in productivity. Thirdly, demand for a wages policy comes from the planners whose calculations are nullified if the wages section of the economy is free to follow its own course, while the rest of the economy is fitted into a definite plan.

If a wages policy is desirable, how is it to be promoted? Experience in the United States and Western Europe has not been encouraging. In Britain the trade unions dislike any radical departure from traditional procedures. Nevertheless, wage claims tend to conform to a particular pattern. At one time it was the practice to present wage claims to the most prosperous industries first. Now the practice is to begin with other industries and then proceed with a bigger demand to the prosperous ones.

A wages policy cannot be considered in a vacuum but must be taken in conjunction with other aspects of economic and financial policies. Full employment demands the co-operation of the major economic groups in the community if inflation is to be avoided. A wages policy which could of necessity only be formulated by national negotiations at the very highest level would meet with no success in this respect.

PRICES AND GOOD MANAGEMENT

The recent news that Marks and Spencer are to cut the prices of certain goods has a much wider significance than simply in connection with the retail of consumer goods. It is an outstanding example of the results of good management thinking. Marks and Spencer have said that the price cuts do not involve any lowering of normal profit margins. The reductions represent genuine savings from reduced costs. It should be noted that these economies are not being made by a large untidy management structure which has suddenly found how to run its business efficiently, nor is it based upon rule of thumb prescriptions and high-sounding management formulae. These price reductions are being made by a management which is already very efficient by normal standards.

Some of the reductions are due to the lower prices of certain raw materials, especially wool, but most of the gains have been made by fresh thinking. Bulk buying, improved methods of distribution (such as pre-packing) and concentration on a few standard lines have all played a part. Significant economies have been made by fresh thinking on well-established routines and paper work. Even the most sacred of standing instructions (such as locking storerooms) have been challenged and changed—thus reducing delays and improving morale at the same time. Staff no longer clock on and time-keeping has been improved in consequence. Forms have been simplified and increased responsibility given to local managers.

Here is, in other words, an outstandingly successful case of work study intelligently applied. It shows that even when there is strong pressure from rising costs, if a management is prepared to test every attitude and every procedure against the standard of suitability to achieve its particular end, very substantial improvements can be made not only in cost but also in morale among the workers and goodwill with customers.

FOREMEN INTO MANAGERS

The need to look upon foremanship as " one step on the way to higher management " was stressed by Mr. W. W. Ferguson, the education and training officer of James Williamson and Son Limited, in a paper delivered to the British Institute of Management conference on management development. Mr. Williamson's thesis was that management and supervision are part of one another and not " two separate and distinctive things." More attention should be paid to the recruitment of foremen, and firms should avoid the type of selection, " on the basis of individual craftsmanship or length of service " which leads to inadequate standards of foremanship and to foremen being used as " the pawns of managers." Mr. Ferguson expressed his concern at the lack of management resources to organise and control the scientists, technologists and engineers who will come to industry from the colleges within a very few years from now. Already there is wastage of this type of manpower, despite the acute shortage which prevails in most places, because the scientist or engineer is often inefficiently utilised.

Mr. Ferguson argues strongly that the growing complexity of production and the increasingly important part which machines are playing in the process makes the need for training in human relationships " one of the most important single aspects of foremanship training." It tends to increase the thought-content of the jobs that remain and Mr. Ferguson advocates some form of training which will teach the foreman " how to think instead of what to think."

There is certainly a growing need to recruit from the ranks of shop-floor supervision for a greater proportion of management posts. Often the ability is there in plenty and also the confidence necessary to inspire confidence in others. It is only the development of certain qualities and the teaching of some new skills (for example, to write a clearly worded memorandum or letter) which is needed to open up a vast and largely unexploited source of managers.

MANAGEMENT ON A LARGE SCALE

Much new material on the Polish economy is given in a special article in the Economic Commission for Europe's *Economic Bulletin for Europe*. The period of the six-year Economic Plan (1950 to 1955) was one of intense activity concentrated on heavy industry. This increased industrial capacity and raised output to double the 1949 value. But growing spending on defence and the neglect of agriculture together meant that living standards did not benefit. Indeed personal consumption per head actually fell between 1950 and 1953 and only improved in 1954 when new policies involving defence cuts, a general slowing down in investment and increased incentive payments to farmers were introduced.

Industrial output, which grew at 13 per cent. per year over the 8 years up to 1955, has now settled at about 9 per cent. But development has been patchy. Coal production meets rising home demand but permits no increase in exports. Electric power continues to be a bottleneck. In some branches of engineering, growth of capacity has outpaced the supply of raw materials, and intermediate products.

The E.C.E. experts see three major problems for the future. First, the need to raise exports to reduce present dependence on foreign credits and ensure adequate supplies of imported raw materials and equipment. Second, the need to increase output of the " bottleneck " products, notably electric power. Third, the present very inadequate housing standards must be improved, if labour mobility is ever to be increased. So far as farming is concerned, collectivisation is now a long-term goal and there is no longer discrimination against private farmers.

The big question is whether Poland's planners can give the wage earners the incentives needed if they are to hit the ambitious targets of the next six-year plan. Unless the workers have some assurance that they will share in increased productivity and output, plans for increased investment will be self-defeating.

Metals and Materials

PHYSICAL PROPERTIES OF GEM STONES

Gem stones figure under a bewildering variety of names, but there are actually only ten kinds of crystal which are commonly cut as gems, namely, diamond, corundum (ruby and sapphire), beryl (emerald and aquamarine), topaz, spinel, garnet, tourmaline, zircon, chrysoberyl (alexandrite and cat's-eye), and olivine (peridot). In the course of a discourse on "Gem Stones," delivered at the Royal Institution, London, on January 31, Sir Lawrence Bragg, F.R.S., added that quartz (silica), though so common, perhaps deserved a place in the list on account of its attractive varieties, amethyst and cairngorm. The colours of gems, he went on, were for the most part due to impurities, and were very variable. For instance, a crystal of pure aluminium oxide (corundum) was quite colourless, but if it contained a little chromium as impurity it became deep red (ruby). Titanium oxide turned it into a blue sapphire, and other impurities made it yellow, green or pink. Emeralds were beryl crystals coloured grass-green by chromium, whereas the same crystals were sea-green aquamarine when they contain a little iron, and could also be yellow or pink. It was all these shades of colour which had led to so many names for the varieties of each kind of crystal. It was their refraction and dispersion of light which gave gems "fire" and they were cut in such a manner as to bring out their full beauty; some varieties of gems changed colour when viewed in different directions.

Many minerals which would otherwise make fine stones were unsuitable because they were too soft. A gem must be equal or superior to quartz in hardness because dust was full of silica particles and softer material soon became scratched and lost its polish. Other minerals had the qualities of hardness and transparency required for a gem, but lacked colour or fire and therefore were uninteresting.

MATERIALS FOR MARINE SUPERHEATERS

The trend to higher steam temperatures and the deterioration in the quality of the fuel oil available has made the problem of the choice of suitable materials for superheater tubes and supports one of the most pressing boiler-design problems in marine steam-turbine machinery. In a paper on this subject, read before the Institute of Marine Engineers in London on January 14, Mr. D. W. Crancher, assistant chief engineer (boilers), Design Department, Pametrada, Wallsend-on-Tyne, Northumberland, discusses the creep and corrosion resistance, mechanical strength and other properties of six tube steels developed in this country and covering, as far as creep strength is concerned, a range of allowable metal temperatures up to 1,230 deg. F. The six materials are: mild steel for tube temperatures up to 900 deg. F.; 0·5 per cent. molybdenum steel for temperatures up to 1,000 deg. F.; 1 per cent. chromium, 0·5 per cent. molybdenum steel and 0·5 per cent. molybdenum, 0·25 per cent. vanadium steel, both for temperatures up to 1,050 deg. F.; 2·25 per cent. chromium, 1 per cent. molybdenum steel for temperatures up to 1,070 deg. F.; and austenitic steel of the 18-12-1 chromium, nickel, niobium type, for temperatures up to 1,230 deg. F.

Ash attack on tubes and supports may become a serious problem, as tube-metal temperatures approach 1,150 deg. F, and the author states that there now appear to be at least two methods of treating residual fuel to prevent ash fouling and corrosion. These are the removal of the contaminating sodium by means of a magnesium sulphate washing solution and the use of additives to raise the melting point of the ash.

GLASS-FIBRE SHEET DEVELOPMENT

What is considered to be one of the largest presses in this country devoted exclusively to the production of glass-fibre flat sheet is now in operation at the Permaglass Division of Permali Limited, Bristol-road, Gloucester. It is a multi-daylight unit with automatic temperature control and high-pressure hot-water heated platens, working at a pressure of 450 lb. per sq. in. The standard sheet produced measures 70 in. by 34 in. and more than 30 different grades using phenolic, melamine, polyester or epoxy resins, combined with one of several different forms of glass cloth, can be pressed to suit almost any application, although the six basic grades manufactured cover most of the normal requirements of industry.

These comprise: polyester resin with fine or coarse-weave glass cloth for general electrical and mechanical applications; epoxy resin with fine or coarse weave for particular electrical and mechanical requirements; phenolic resin with fine weave for chemical applications; and melamine with fine weave for flame-retarding electrical applications.

METALLIC BORIDES AND THEIR USES

The high melting points of metallic borides, ranging up to 3,100 deg. C., and their hardness, make them compounds of metallurgical interest. Their corrosion resistance, both to noxious gases and to metals in the liquid or gaseous state, has stimulated research into the possibilities of their use in gas turbines and other situations in which their inert character is of importance. Several research organisations are investigating fabrication techniques from the points of view of pressing by powder-metallurgy processes and of forming coatings on metals and alloys. Borides also play a part in Cermets, the new series of metal-ceramic components and they may also prove of use in tools and dies.

In view of the applications and potential uses of borides, it is interesting to note that Borax Consolidated Limited, Borax House, Carlisle-place, London, S.W.1, are now able to supply two series of these materials, one of high chemical purity (not less than 99·8 per cent.) and the other comprising technical grades of minimum purity of the order of 99 per cent. The 11 compounds in the pure series are dense, hard powders of average particle size of 10 to 50 microns, but the 14 compounds in the technical series are finer, averaging from 5 to 10 microns in particle size.

Several borides of the more important metals, such as chromium, molybdenum and tungsten, appear in one or both of the purity ranges as well as borides of some of the less common metals such as titanium, zirconium, vanadium, niobium and tantalum.

COAL BLENDING AND COKE QUALITY

It is well known that the quality of hard coke, as generally measured by the 1½ in. shatter index, is greatly dependent on the rank of the coal used for coking and the duration of its "fluid" state during heating. In a paper entitled "The Shatter Strength of Cokes from High-Volatile Coals: Use of Plastometer Measurements on Blends for Test-Oven Experiments," presented in London recently before the Institute of Fuel, the authors, Dr. D. W. Gillings and Mr. W. Lawson describe work carried out at the Coal Research Establishment, National Coal Board, Stoke Orchard, Cheltenham, on a large number of blends carbonised in a test oven, using 10 cwt. charges.

As the result of their work the authors conclude that the addition of high-rank coals to high-volatile coal blends can be very effective in raising the shatter strength of the coke, the rise obtained with relatively small percentage additions being much greater than that anticipated on the basis of rank alone. Such additions may be so small as to be permissible in practice on economic grounds. An increase in the "viscosity" of a coal blend, moreover, can be obtained with materials other than a high-rank coal. Such materials include low-rank non-coking coals which can be used in a significant proportion added to the readily-fusible coking coals, either with a small gain or, at least, with no loss of shatter strength. Some low-rank coals, however, cannot be used in this way.

TUNGSTEN ELECTRODES FOR ARGON ARC PROCESS

To improve the quality of the welds made by their Argon arc process, British Oxygen Gases Limited, Spencer House, St. James's-place, London, S.W.1, have now introduced two new types of tungsten electrodes. Under good welding conditions, a tungsten electrode is virtually non-consumable, provided it is chemically pure. The addition of small percentages of thorium and zirconium, however, improve emissivity. This, it is pointed out, is evidenced by superior arc-striking qualities, improved stability at low welding currents and the almost total absence of arc "wander." One of the new electrodes contains a total of 2 per cent. of thorium and the other, 1 per cent. of zirconium.

CEMENT FOR SETTING PAINT BRUSHES

A new epoxide-resin brush-setting cement, for use in paint-brush manufacture, has now been introduced by Bakelite Limited, 12-18 Grosvenor-gardens, London, S.W.1. The material is stated to possess excellent resistance to the wide range of solvents in common use at the present time. It can be cured at room temperatures but the curing time can be reduced to a matter of minutes by using an oven or infra-red heating. By employing a carefully-designed assembly line very rapid production rates can be achieved.

STEEL IN AGRICULTURE

A colour film with sound projection, entitled "Earth is a Battlefield" was recently shown in London by the British Iron and Steel Federation. The film has been made by the Larkins Studio, in association with the Film Producers Guild Limited and, in animated cartoon form of a somewhat bizarre type, shows how iron and steel have served agriculture from medieval times until the present. The film, which is available in 16 mm. and 35 mm. forms, is obtainable on loan on application to the Public Relations Department of the Federation, Steel House, Tothill-street, London, S.W.1.

Book Reviews

THE USE OF STATISTICS IN I.C.I.

Statistical Methods in Research and Production. Edited by OWEN L. DAVIES. Third edition. *Oliver and Boyd, Tweeddale Court, Edinburgh*, 1. (45*s*.)

Ten years ago, Imperial Chemical Industries Limited commissioned a distinguished team of authors to prepare a handbook which would give wider publicity to the statistical methods in use within the company's organisation, and, at the same time, help new staff to acquire a working knowledge of the subject. That handbook has now passed into its third edition, having been completely revised and enlarged. It contains within its covers particulars of all the statistical methods which are likely to be of use to research and process workers in most industries.

It is to the authors' credit that the examples, which are all drawn from problems in the chemical industry, illustrate the theory clearly and do not suffer from bias. The reader, at first, may well be in two minds as to the aim of the book, for, although the format and text is that of a text-book, it abounds in practical applications. At the same time, the book does not dwell on any of the mathematical proofs of statistical theories; these are either neatly filed away in the concise appendices which follow each chapter, or the source of the proofs is quoted in the bibliographies which also come at the end of each chapter. It is, then, a handbook, in an agreeably unconventional style, but one which will be best appreciated probably by persons at and above degree mathematics standard.

The book falls into four groups of chapters. The first group, of three chapters, explains general statistical concepts, measures of range, typical values and variations about these values. The second group, chapters 4 and 5, is perhaps the most valuable. Chapter 4 contains a lucid explanation of the use of confidence limits for mean values, standard deviations, and ratios of standard deviations. In it, the emphasis is on confidence limits rather than on the probably better-known tests of significance, because, as the authors rightly claim, the former contain, so far as research is concerned, all the information contained in the latter. The next chapter embodies recent ideas on the economics of experimentation. Tests which give guidance on the amount of routine testing required or on the number of comparative experiments that can be justified economically, are clearly laid out, accompanied by a useful range of examples. Methods are given applicable to cases where the background information is known and to those where it is unknown. The term " background information," it may be noted, comprises a knowledge of the prior distribution of the experiment and of the costs of making wrong decisions and experimentation. The solutions embody an elegant feature of plotting the S-shaped power curves to a semi-logarithmic scale; the slope of the resulting straight line is the acceptance characteristic which can thus be completely determined by two probability points on it.

The third group, chapters 6, 7 and 8, covers the analysis of co-variance by simple regression methods. Hierarchic and cross-classification methods, and a combination of the two are illustrated. The whole of chapter 8 is devoted to multiple and curvilinear relationships with the accent on the difficulties of interpretation of relationships between several variables. The last group, also of three chapters, is concerned with probability distributions. It covers the Poisson, binomial and Chi-squared distributions, and, in the last two chapters, sampling inspection procedures; their costs and reliability are fully covered. There is also a discussion on the commonly misunderstood distinctions between simple, multiple, sequential and stratified sampling.

The general layout, with all references to text, formulae and appendices numbered decimally, makes for easy reference. The book also contains a useful set of statistical tables and, another excellent feature, a nomogram for interpolating statistical tables for probability levels other than the common ones. Altogether, this handbook should make a worthwhile addition to personal, as well as to technical, libraries.

ENOUGH TO MAKE DIAMONDS

Physico-Chemical Effects of Pressure. By S. D. HAMANN. *Academic Press Incorporated*, 111 *Fifth-avenue, New York* 3, N.Y. (8.50 dols.); and *Butterworths Scientific Publications*, 4 *and* 5 *Bell-yard, London, W.C.*2. (42*s*.)

The effect of high pressures on physical and chemical processes is one of immense academic and practical interest. Scientists throughout the ages have realised that the real tests for any hypothesis is to see if it fits the known facts under extreme conditions of the variables involved, and this was originally, no doubt, the main reason for the considerable interest in high pressures. Within the last few decades, however, it has been realised that some chemical processes become practicable under high pressure and, in others, the yield is considerably raised. In this country a fine example of this has been in the production of polythene which was only made possible by the commercial application of high-pressure techniques to the processes involved.

Maybe the most startling development in the high-pressure field has been the production of diamonds by the General Electric Company in the United States and the A.S.E.A. Company in Sweden. This has involved maintaining pressures of the order of 100,000 atmospheres (656 tons per sq. in.) or more, and temperatures in excess of 2,000 deg. F. for prolonged periods. Though the methods employed have not been disclosed it has been announced that the General Electric Company are ready to start commercial production of industrial diamonds. It has also been disclosed that they have managed to produce boron nitride in a crystalline state having a cubic structure instead of the hexagonal structure normally found in nature. This material, which has been named Borazon, is harder than diamond, and it can be imagined that it may have a considerable commercial value. The possibility of producing other materials under these extreme conditions cannot be disregarded.

It can be readily realised that there are considerable practical difficulties in the construction of high-pressure equipment and many of these have only been overcome by experience rather than analysis. Consequently the construction of high-pressure equipment must form an important section of any book on this subject. Some space in the book under review has been devoted to the production and measurement of high pressure, but it is to be regretted that the author has fairly obviously not read the extensive literature on the yield, plastic flow and fracture of thick-walled cylinders made from a ductile material. It is just not true that " engineers have proposed a number of criteria for the onset of yield but none of them is really satisfactory." For instance, Professor J. L. M. Morrison (*Proc. I. Mech. Eng.*, vol. 159, page 81 (1948), " Criterion of Yield of Gun Steels ") gives conclusive evidence that the yield and subsequent plastic flow of thick cylinders are controlled to a close approximation by the Mises-Hencky function of stresses. In fact the complete behaviour of a thick-walled cylinder up to the maximum pressure it can contain can be predicted from data readily and easily obtained from a simple torsion test and less easily deduced from a tension test. It is of course true that the strength of cylinders made from extremely hard materials is less well understood.

The opening chapter on the construction of high-pressure equipment unfortunately gives a wrong impression of the subsequent chapters which are extremely well and ably written. They contain a very good résumé of the present state of knowledge on the effect of pressure on the compressibility of gases, fluids, and solids, phase changes under pressure, transport properties, equilibria of chemical reactions under pressure, etc. The last chapter on miscellaneous effects of pressure gives some insight into the immense fields awaiting exploration, such as the possibility of producing ammonium " metal."

There is a very extensive bibliography at the end of the book which refers to many of the papers published since the very comprehensive review written by Bridgman (" Recent Work in the Field of High Pressure," published in *Reviews of Modern Physics*, January, 1946).

Except for the opening chapter on the design and construction of high-pressure equipment this book can be recommended to those who are interested in the effect of high pressures on physical and chemical processes, including those engineers who are involved in these processes.

CHANGING PATTERNS

Jane's All the World's Aircraft, 1957-58. Compiled and edited by LEONARD BRIDGMAN. Assistant Compiler JOHN W. R. TAYLOR. *Sampson Low, Marston and Company, Limited*, 25 *Gilbert-street, London, W.*1. (105*s*.)

For those who can find time to browse over consecutive volumes of *Jane's All the World's Aircraft*, many interesting patterns in aeronautical development may be traced out. Statistics given for " Airlines of the World," both scheduled and non-scheduled operators, permit comparison of the relative growth of various companies and of the way they choose their fleets—some appearing to believe that variety is the spice of life while others show a marked affiliation to one manufacturer. The sections " All the World's Aeroplanes " and " All the World's Engines," reveal not only technical trends but also the changes in relative design and manufacturing vitality of the various nations. This year, for example—quoting from Mr. Bridgman—Austria and Bulgaria make " a modest reappearance after an absence of 20 years," in the one case with a light training aircraft; and in the other, also with a training aircraft and, in addition, a pulse-jet-powered reaction-drive lightweight helicopter. Also appearing for the first time are Eastern Germany —reported to be developing a new four-jet airliner as well as constructing a small transport plane under licence and several gliders—and Egypt, constructing a war-time German-designed trainer. In Western Germany, activity is gaining momentum but, with so many lost years to catch up, design projects are on a small scale and manufacture is confined mainly to the licensed construction of several French military aircraft.

The descriptions of Russian aircraft are, inevitably, somewhat scaled-down in comparison with those of the Western world. " The Russian section of 14 pages does not contain much new military information, largely because the 1957 military display . . . was cancelled at the last moment. Instead Russia sprang a surprise by revealing the very real existence of three new gas-turbine-powered transports . . . " Whether or not the sputniks should have a place in

Jane's remains to be seen next year—they appeared too late in the year anyway for inclusion in this year's "Aeroplanes" or the guided-missiles sub-section. Nevertheless they earn the comment, in the preface, that they "prove that Russia is far in advance of the West in the means of projecting . . . weighty objects into space."

Guided missiles are treated in this volume, as last year, in a tabulated sub-section at the end of "Aeroplanes" supplemented by references under individual aircraft manufacturers. Naturally, this has grown and some of the details are beginning to emerge. With more information becoming available, guided missiles next year will be promoted to the distinction of a self-contained section.

NEW BOOKS

Technology for Sugar Refinery Workers. By OLIVER LYLE. Third Edition. *Chapman and Hall Limited, 37 Essex-street, London, W.C.2.* (70*s.*)

In the words of the author, the main purpose of this book is "simply to help members of refinery staffs to a better understanding of sugar refining." The present, third, edition has been revised, re-arranged and enlarged. Four new chapters have been added, as well as upwards of 50 new sections in the original chapters. The subject matter of all the chapters is divided up into sections, each having a heavy-type title and a number, and ranging in length from a third of a page to several pages. The index at the end of the work is a section index and there are no references to pages. In addition to the chapters on the production, treatment and refining of sugar, there are others of more general interest which deal with such matters as steam boilers, electricity and its production and use, pumps, centrifugal machines, evaporators, filtration and the heat balance.

Soldering Aluminium. Information Bulletin No. 23. *The Aluminium Development Association, 33 Grosvenor-street, London, W.1.* (2*s.*)

The latest *Information Bulletin* published by the Association, No. 23, deals with the soldering of aluminium and its alloys. There are already five *Bulletins* which concern the joining of these materials; Nos. 5, 6 and 19 relate to welding, No. 8 to riveting and No. 22 to brazing. At one time aluminium was regarded as being difficult to solder but as a result of developments during the last few years, several practical soldering techniques are now available. The methods used and the equipment needed are described in detail in the present publication.

Advanced Mathematics for Technical Students. Part II. By H. V. LOWRY and H. A. HAYDEN. *Longmans, Green and Company, Limited, 6 and 7 Clifford-street, London, W.1.* (21*s.*)

The volume covers work normally done by students taking mathematics as a subject in Part II of an engineering degree. The second edition differs from the first—published in 1950—in the treatment of the operational calculus, which is now approached by the method of Laplace transforms. The work covers the infinitesimal calculus, moment and product of inertia, envelopes, centre of curvature, plane motion of a lamina, and instantaneous centre, differential equations, and their application; difference equations and interpolation, determinants and matrixes, three-dimensional co-ordinate geometry, spherical trigonometry; differentiation and integration of functions of several variables; line, surface and space integrals; Fourier series and harmonic analysis; motion of a system of particles and of a rigid body; energy methods, solution of differential equations by infinite series and partial differential equations. Answers are provided to the exercises set at the end of each chapter, which include a number of London University examination questions.

Earth Pressures and Retaining Walls. By WHITNEY CLARK HUNTINGTON. *John Wiley and Sons Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (11 dols.); and *Chapman and Hall Limited, 37 Essex-street, London, W.C.2.* (92*s.*)

Written primarily as a work of reference for the structural engineer and the graduate student concerned with the design of retaining walls, Professor Huntington's book is intended to bridge the gap which often exists between retaining-wall design and that portion of soil mechanics which deals with earth pressures and foundations. The book emphasises principles and offers numerical solutions; it gives also typical designs and tabulated computations. Special consideration is given to the design of counterfort walls, and to the "trial wedge" method of computing earth pressures.

Catalysis in Practice. Edited by C. H. COLLIER. *Reinhold Publishing Corporation, 430 Park-avenue, New York 22, N.Y.* (3.95 dols.)

The seven papers comprising this book were originally presented at a meeting held in April, 1957, in Philadelphia, under the auspices of the Philadelphia-Wilmington section of the American Institute of Chemical Engineers and the School of Chemical Engineering of the University of Pennsylvania. The seven chapters deal with the choice and commercial preparation of catalysts, fixed-bed and moving-bed systems, the economics of catalyst processes, operating problems in catalytic processing, and trends and prospects in catalysis.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Magnetic Tape Recorder. AMPEX CORPORATION, 934 Charter-street, Redwood City, California, U.S.A. Technical details of mobile and airborne magnetic tape recorder for obtaining dynamic data of laboratory standard. The frequency response on the tape is up to 100,000 cycles per second at 60 in. per second, and 2 to 14 recording tracks are available. Photographs of typical applications and tables of the various applications of the instrument are given in a 16 page brochure.

Thermal Relays. MERCIA ENTERPRISES LTD., Godiva House, Allesley Old-road, Coventry. G-V thermal relays are made under licence; their principle of construction has been used for a number of years in the U.S.A. They have wide application in electronics. Product and application data bulletins are contained in a folder that also gives a general introduction and miscellaneous information. Illustrated leaflets.

Flour Milling. THOMAS ROBINSON AND SON, LTD., Rochdale. "Pneu-roll" rollermill, type MEm. A new design based on previous Robinson roller-mills, but incorporating numerous improvements, this machine is of reduced overall size, but is designed to operate at high speed with very large outputs. Eight-page leaflet, punched for insertion in Robinson loose-leaf catalogue.

Concrete Building. PETER LIND & CO. LTD., Romney House, Tufton-street, Westminster, S.W.1. Work completed by company, illustrations and brief descriptions: industrial and commercial buildings, silos, collieries and gasworks, power stations, piling and foundations, bridges and marine works. Booklet entitled "Concrete Achievements."

Shaping Machine. CROWTHORN ENGINEERING CO., LTD., Reddish, Stockport. Crank-type shaping machine of 19½ in. stroke, complete with motor and starter and swivel base vice. Extra equipment available includes an indexing head and spur and bevel gear generating attachments. Illustrated leaflet.

Thread Measuring. W. H. MARLEY AND CO., LTD., 105 High-road, New Southgate, London, N.11. Thread-measuring parallels, for use with a micrometer, covering Whitworth, Metric, B.A., U.S. and Unified threads in all sizes. Also dial-gauge comparator for screw threads, incorporating the same principle. Two illustrated leaflets.

Surface Grinding. STUART DAVIS, LTD., Much Park-street, Coventry. Details of the range of rotary table surface-grinding machines made by Karl Mengele and Söhne, Günzburg/Donau, Germany. Illustrated leaflet.

Cement. LAFARGE ALUMINOUS CEMENT CO. LTD., 73 Brook-street, London, W.1. Different cements useful to the maintenance engineer: rapid-setting, corrosion-resistant, refractory and insulating. 32 page booklet.

Tubular Sections. ACCLES AND POLLOCK LTD., Oldbury, Birmingham. Sizes and shapes of special tubular sections made by company. Handbook.

On the Shelf

By Frank H. Smith

The Federation of British Industries issues a *Selected British Technical Journals* booklet chiefly for the benefit of former Overseas Scholars of the Federation and other overseas engineers trained in this country. It can also be obtained from 21 Tothill-street, London, S.W.1, in return for a florin. The journals are all "commercials" and none of the society or institution publications is given. Publishers, subscriptions and nature of contents are indicated.

The Coil Spring Federation Research Organisation, Hoyle-street, Sheffield 3, is contemplating a book containing all specifications relevant to springs and spring materials. This would include all the appropriate British Standards and Government-department standards as well as international and European standards. The book would be in loose-leaf form to facilitate amendments and alterations and the contemplated cost is 12*s.* 6*d.* The organisation wishes first to obtain some idea of what the demand would be and anyone interested is asked to get in touch with them. I cannot help wondering, though, what will be the reaction of the publishers of standards.

Russian translation is reaching such dimensions that I can afford only to mention such items as come to my notice. The organisation for physics would appear to be Consultants Bureau Incorporated, 227 West 17th-street, New York 11, U.S.A., which will, no doubt, be pleased to forward their publicity on such items as *Physics of Fission* in complete translation—30 dols. The same people are preparing a *Russian-English Physics Dictionary* at 50 dols., but you will have to wait a year for that.

Certain branches of engineering and science have central registers of translations in their particular fields. It is not necessary to keep a list of individual translations—although that would be an ideal—but a register of bodies and organisations having a translation service is useful so that one can obtain their lists as and when published. This great thought arises out of the sight of library translation number 64 of the Cement and Concrete Association, 52 Grosvenor-gardens, London, S.W.1. It is on "Machines and Equipment for Concrete Road Construction," and is from the German (*Baumaschine und Bautechnik*) of G. Streit.

The years 1881 to 1957 inclusive are 77 which is a funny interval to celebrate. But why not? *Brown and Tawse* 1881-1957 is a history of the B. & T. Group of Companies, compiled by the youngest member of the board—Mr. Douglas Rae. It is an excellently and elegantly produced book of the type that is treasured by employees and their descendants. It is also the sort of book that is invaluable to compilers of, and investigators into, social and economic history. The book raises a somewhat curious point. Though Brown and Tawse can muster a mere 77 years, they have taken over George Stephen and Son, Limited, of Dundee, founded in 1814, and Fraser and Fraser, who date back to 1825. How does a parent celebrate the anniversaries of its offspring when the parent is younger than they?

It is rather pointless at this late date to comment on the 105th annual report of the libraries committee of the Manchester Public Libraries. This is a pity because I should have liked, in all due humility, to have done so. Manchester's public libraries are world renowned and the annual report is a delightful production. Better luck this year perhaps. I will just quote from the section on "Technical Library"—"it seems very apparent that the ever-growing student population and the accelerating importance of technology in everyday life, brought on by the tremendous advances of the last decade, will mean that technical publications will be needed more and more in the years ahead."

Research and Development

HIGH-SPEED PHOTOGRAPHY: A TOOL FOR THE ENGINEER

*By D. P. C. Thackeray, A.Inst.P.**

The last half century has seen the techniques of high-speed photography, once in occasional use in ballistics and zoological laboratories, developed to become routine approaches to many problems in engineering. In particular, high-speed photography has contributed powerfully to the development of reliable fast mechanisms, since it provides the principal group of visual methods for extending the time resolution of the eye and brain to very short durations. Additionally, it provides a permanent record susceptible, if required, to repeatable analysis after long intervals. This carries with it, in the case of some camera systems, the disadvantage of providing more material to be analysed than can be handled by the available staff. There is therefore much to be said for choosing the camera system to provide no more information than the minimum desirable. It is heartening to note that some steps have already been made[1,2] towards the analysis of high-speed photographic systems, and classification of camera types, in terms of communication theory; and that it is possible to predict[3] the ultimate performance of some camera systems in such terms. It is to be hoped that this approach may eventually lead to the production of some camera designs of optimal performance to augment those in use at present.

Many problems requiring the use of high-speed photography are currently tackled with a variety of commercially built ciné-cameras: by utilising any one of a number of mechanical/optical methods of image position stabilisation these may record on sub-standard ciné-film up to several thousand frames per second. Typical forms of such ciné-cameras have been described previously in ENGINEERING,[4] omitting however any description of the high-power lighting gear[5] that is commercially available for use with such cameras. These and other similar cameras, as well as a wealth of other types of cameras and high-speed photographic techniques, are described also in other literature, some of which has been listed in the appendix to this article.

HIGH-SPEED CINÉ-SYSTEMS

One of the simplest extensions to this image stabilised ciné technique consists in providing, in addition to or instead of the stabilising prism, a suitably synchronised high-power source of intermittent illumination. Typical high-power stroboscopic flash-gear, available commercially,[6] provides several thousand consecutive flashes, of duration usually between 0·1 and 5 microseconds, at repetition rates up to 25,000 per second. Fig. 1 shows a few frames from a record of the swimming movements of a shrimp, taken in this manner by Dr. R. H. J. Brown, of Cambridge. It is possible, for somewhat lower light intensities, to use the light emitted from a cathode-ray tube phosphor, at rates up to about 500,000 per second.[7]

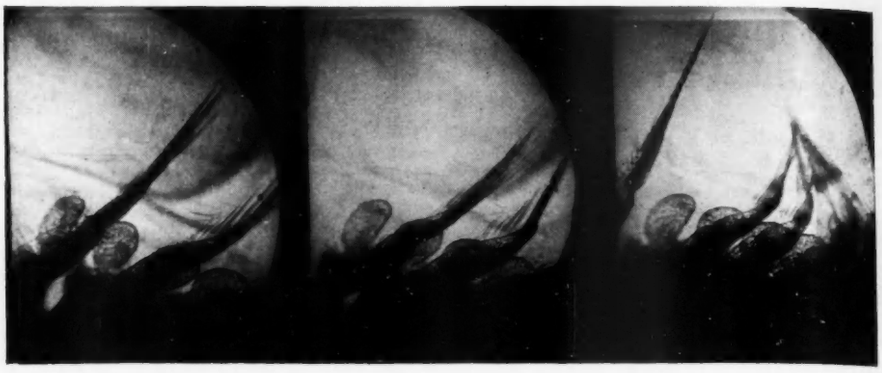


Fig. 1 Swimming movements of a shrimp: a few frames from a record taken by stroboscopic light.

For such high framing rates it is not always possible to use a moving-film camera. Instead, the film may remain stationary while the image is swept across it by means of a rotating mirror. A commercially available camera[8] utilising this device, will take up to 25 pictures at rates up to 2·4 million per second of both self luminous and non-self luminous phenomena.

Other optical methods may be used to provide a sequence of pictures, in cameras containing no moving parts.[9] For instance, where a small number of pictures is required of an event viewed by transmitted light, the Cranz-Schardin system may be employed. Fig. 2 (upper part) shows a field lens, the aperture of which determines the size of the field of view, imaging a group of sparks, one upon each of a number of similarly grouped camera lenses. These lenses focus the plane of the event on to a photographic plate. If now the sparks are triggered to occur in succession, a sequence of pictures of the event, recorded at the instants of the sparks, is obtained upon the photographic plate. Alternative light sources are possible. The cathode-ray tube shown in Fig. 2 (lower part), for instance, enables silhouette pictures to be obtained at rates up to 500,000 per second, at exposure times of 1 to 2 microseconds per frame.[10] Fig. 3 and 4 show two sequences obtained with a simple camera (Fig. 5) of this type, of a rifle bullet passing through a strip of glass. With spark light sources, exposure times of much less than 1 microsecond are possible. Fig. 6 is a silhouette picture of a bullet in flight taken by this means.

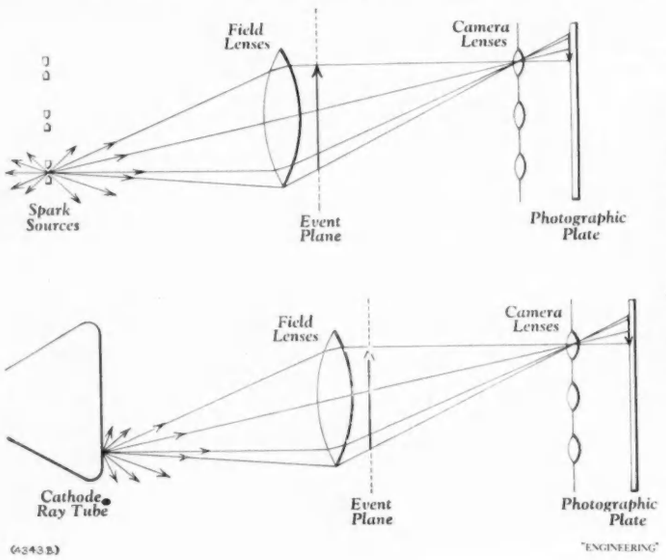


Fig. 2 Cranz-Schardin system of high-speed photography. In the upper diagram electric sparks are used for illumination and photographs can be taken at over one million frames per second. In the lower diagram the light source is a cathode-ray tube and pictures can be taken at up to 500,000 per second.

A third group of camaras giving a ciné-record comprises those employing image sampling methods.[11] In these, some spatial resolution is sacrified by dissecting the image into a dot pattern, as in Fig. 7. These dots can be stored photographically in a variety of ways, much as a pulse sequence may be coded for storage in digital computation. In recent practical cameras of this sort,[12, 13] the dots retain their spatial relation on the photographic emulsion, but are spaced at intervals large compared with the dot size (Fig. 9). Hence it is possible to interlace many such dot pictures by introducing relatively small movements of the photographic plate, or other component in the system, between pictures. A commercial form of this camera[13], made by J. Langham Thompson, Limited, Bushey Heath, Hertfordshire, is illustrated in Fig. 8. In it a framing rate of up to 150,000 per second is achieved. Some 75,000 image points contribute to each of the 300 frames that may be stored, on a single photographic plate, in each sequence. Fig. 10 shows a selection of frames from such a sequence, taken with this camera, of a revolver bullet passing through a wooden plank. The image quality approximates that of a half-tone illustration, and achieves a spatial resolution equivalent to that of a substandard ciné-film record. A similar camera of great simplicity, constructed in the laboratory, is illustrated in Fig. 11. With this was taken the sequence, Fig. 12, of a mercury-fulminate explosion. The light collecting power of these particular cameras is sufficient to enable the sequence to be recorded on a slow process emulsion, non-self luminous events being adequately lit by photo-flash bulbs.

Even under these conditions it is possible to take ciné-micrographs an order of magnitude faster than has been previously achieved. A recent investigation[14] into the burning and detonation of single crystals of explosive materials has been conducted with a ciné-microscope of this sort. Framing rates of 20,000 and 50,000 per second were used, the events being recorded

* Laboratory for Research on the Physics and Chemistry of Solids, University of Cambridge.

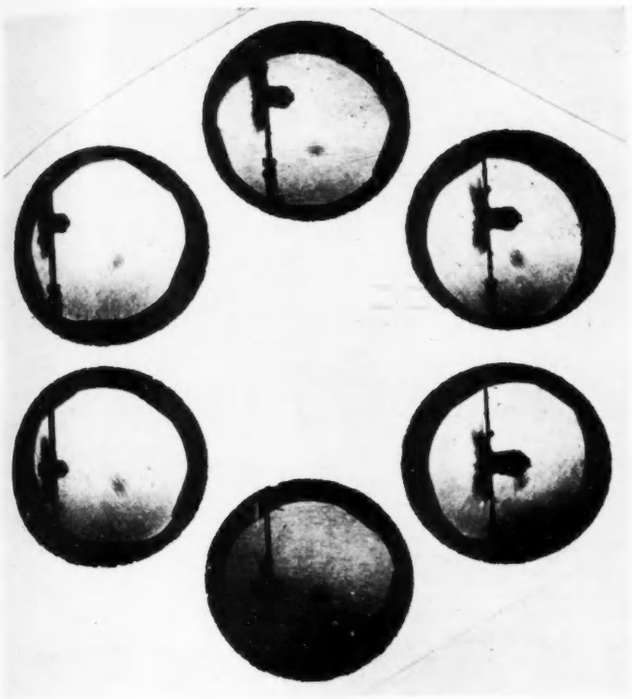


Fig. 3 Photographs of a bullet passing through a strip of glass taken by the camera shown in Fig. 5 set up as indicated in the lower diagram of Fig. 2.

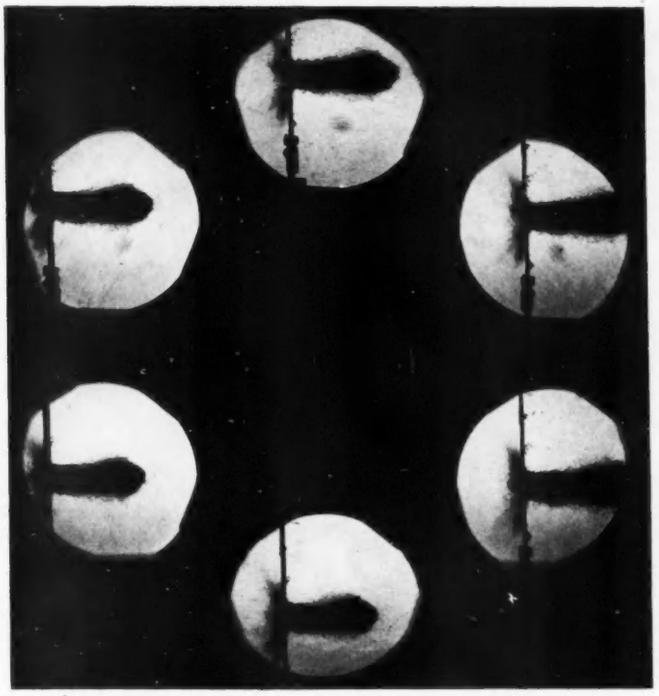


Fig. 4 Later stage of event shown in Fig. 3. The bullet is now clear of the glass although obscured by debris.

Fig. 5 Camera of type illustrated diagrammatically in Fig. 2, with which Figs. 3 and 4 were taken.

at linear magnifications of 500 and 200, respectively. Apparatus has been developed concurrently[15] to enable events recorded by this range of image dissection cameras (and others), to be lit by an electronic flash of rectangular intensity/time waveform as an alternative to chemical photo-flash bulbs.

HIGH-SPEED SHUTTERS

A vital component of many high-speed camera systems is the fast shutter. Where shuttering is not an integral function of the camera itself or of the light source used, or where the use of these alone provides insufficient reduction of exposure time effectively to " freeze " the action, a high-speed shutter can be introduced. The three types to be described become progressively more useful as one wishes to attain exposure durations in the region 10^{-3} to 10^{-6} second; and can be used, in suitable circumstances, down to times of the order of 10^{-9} second.

The Kerr cell shutter is an electro-optical device consisting of spaced conducting electrodes in a dielectric of nitrobenzene. This is inserted between optically crossed Polaroids in the optical system of the camera. If a suitable high electric stress is produced in the nitrobenzene, by the application of a high-voltage pulse to the electrodes, the plane of polarisation of the light traversing the cell is rotated. Some of this light will then pass through the second Polaroid and form an image on the photographic emulsion. In this manner the cell will provide exposure times of approximately the durations of the applied voltage pulses, down to about 10^{-8} second. Fig. 13 shows the improvement obtained in a flash photograph of a projectile hitting a piece of armour plate, when a Kerr cell shutter is substituted for a mechanical shutter. The magneto-optic shutter,[16] operates in a similar manner, but uses a high magnetic stress in a block of high-density glass to produce the required optical rotation.

A third device, the image converter shutter,[17] is electron-optic in character. It consists of a plane cathode of photo-emissive material on which the event may be focused optically, and a plane anode of fluorescent material, sealed inside an evacuated glass envelope. Electrons are emitted from the photo-cathode in proportion to the incident illumination, and in the presence of an accelerating electric field, will be collected at the anode. Suitable focusing fields are applied so that electrons arriving at the anode maintain the same spatial distribution as that in which they were emitted from the photo-cathode. In these circumstances the fluorescent image formed at the anode is virtually identical with that focused optically upon the cathode. In the absence of the accelerating field the emitted electrons do not travel to the anode, so that no second image is formed. For operation as a shutter therefore the tube requires to be fed with voltage pulses of shape and size similar to those used for driving the Kerr cell. It will function however down to times of less than 3×10^{-9} second.[18] Fig. 14 is a picture of a 20 mm. projectile in flight taken with an image converter camera at an exposure time of one microsecond.

This use does not however exhaust the potentialities of the tube; while the image is in its electron state, it may be swept or oscillated sideways by means of a suitable magnetic field. The position of the image upon the fluorescent anode follows the field changes. Hence the tube may afford facilities for fast single dimensional recording with time resolution better than 10^{-9} second,[19] or may be used as a high-speed image stabilisation device.

CONCLUSIONS

While some of the devices mentioned above are tools for the specialist and may never achieve widespread use outside research and development laboratories, there are many types of camera and lighting gear in current commercial production which are simple to use and can provide high-speed pictures of useful quality. It was encouraging to note the keen interest in such gear that was shown by visitors to the exhibition of apparatus for high-speed photography, held in conjunction with the Third International Congress on High Speed Photography, London, 1956. A survey[20] of North American usage of the techniques of high-speed photography, revealed that industrial users comprise 60 per cent. of the total, the United States Government only 15 per cent., and hospitals, universities and similar independent institutions 19 per cent. In the United Kingdom, the demand for information and advice on the employment of high-speed cameras seems to be currently met by consultation with established authorities in the field, or by appeal to specialist firms.[21] However the field is expanding rapidly in some directions and to meet the demands of, for

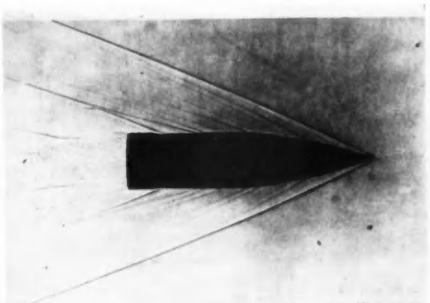


Fig. 6 Photograph of projectile in flight. Electric spark discharge used as illuminant. *Crown Copyright photograph.*

Continuing

Research and Development

instance, engineers working on problems in ultrasonic fluid flow, may well mean that the training and employment of specialists in the field will become an economic necessity.

Acknowledgments.—The author wishes to thank those who have lent him illustrations for use in this article and in the lecture to section A of the British Association, Bristol, 1955, on which it is based and Dr. J. S. Courtney-Pratt for reading and commenting upon the manuscript.

In particular, Dr. R. H. J. Brown, of the Department of Zoology, University of Cambridge (Fig. 1), Mr. J. T. Harris, of the Armament Research and Development Establishment (Figs. 6 and 13, which are Crown Copyright and are reproduced by permission of H.M.S.O.); to Professor H. Schardin, for Fig. 7 and to J. Langham Thompson Limited, for Figs. 8 and 10.

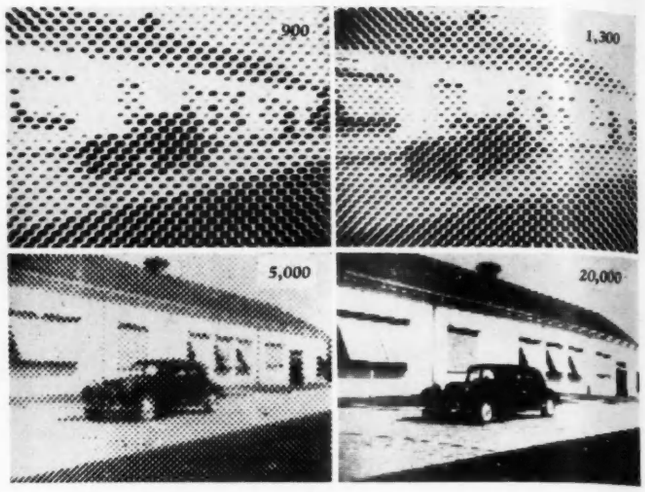


Fig. 7 Four pictures of the same subject illustrating the photographic quality obtained with resolutions of 900, 1,300, 5,000 and 20,000 discrete picture points per frame.

APPENDIX

Literature on High-Speed Photography

There are five books which, between them, form a basic library for the subject.

(*a*) *Lehrbuch der Ballistik*, C. Cranz, Springer Verlag, Berlin 1929 (In German) Band iii, und Ergänzungsband.

These introduce a number of the earliest methods for obtaining single pictures and sequences of pictures by the use of spark illumination. As the title suggests, the applications are principally ballistic; but it is relevant to note that these methods are still in use to-day, with minor or no modifications, and their use is not confined to ballistic problems.

(*b*) *Photographie Instantanée et Cinématographie Ultra-Rapide*, P. Fayolle et P. Naslin, Éditions de la Revue d'Optique, Paris, 1950.

This extends spark illumination techniques almost to the present day, and includes a survey of most other techniques, with particular emphasis on camera systems used in the authors' laboratories.

(*c*) *Flash*, H. E. Edgerton and J. R. Killian, Bramford, Boston, 1954.

This illustrates the development of electronic flashgear in America, with particular emphasis on the use of gear developed by Prof. Edgerton and his associates, some of which is commercially available.

(*d*) *The Photographic Study of Rapid Events*, W. D. Chesterman, Clarendon Press, Oxford, 1951.

(*e*) *High Speed Photography*, G. A. Jones, Chapman and Hall, London, 1952.

These two books cover roughly the same field and provide a general introduction to the subject. Since the approach of the authors is dissimilar, and they have avoided duplication of content to a considerable extent, they must merit equal recommendation.

These books may be augmented by the published proceedings of the three international congresses held so far:—

Washington, 1952. The papers read at this congress were published by the Society of Motion Picture and Television Engineers in their series entitled " High Speed Photography," vols. 1 to 5.

Paris, 1954. Published as " Actes du 2e Congrès International de Photographie et Cinématographie Ultra-Rapide," edited by P. Naslin

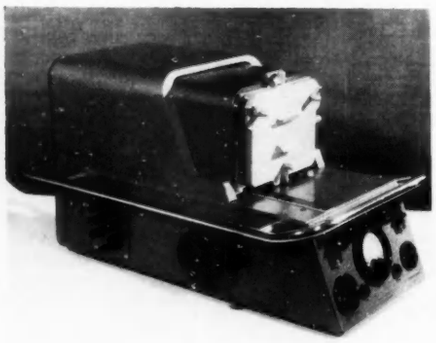


Fig. 8 Commercial form of camera of type illustrated by the diagram in Fig. 9. A framing rate up to 150,000 per second is achieved. Some 300 discrete frames are obtainable from a 5 in. by 4 in. plate.

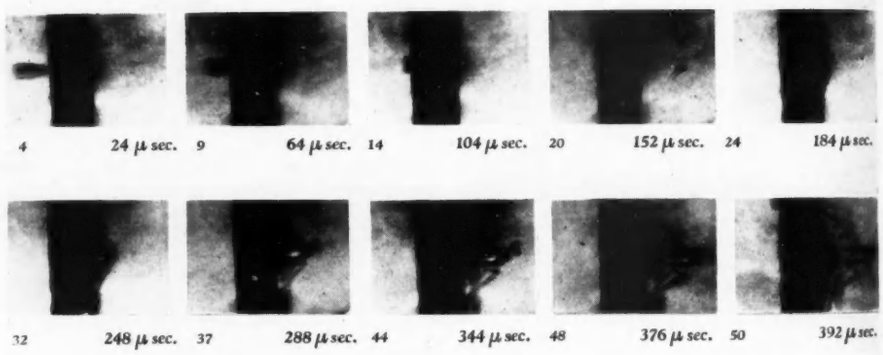


Fig. 10 0·45 in. revolver bullet passing through wooden plank. Sequence obtained with the camera shown in Fig. 8. Framing rate 125,000 per second. Velocity of bullet 7,800 in. per second. The first figure under each is the number of the picture in the sequence and the other the time in milliseconds from the commencement.

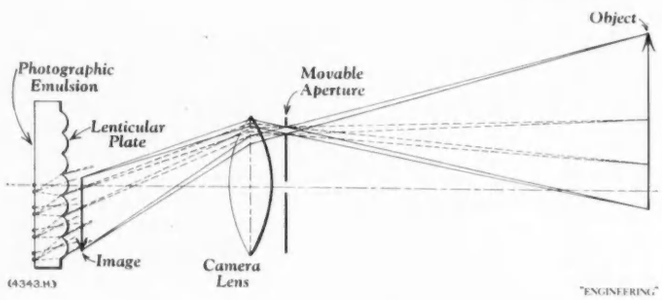


Fig. 9 Optical system of a series of high-speed multiple frame cameras using lenticular plates for dissecting the image into dots.

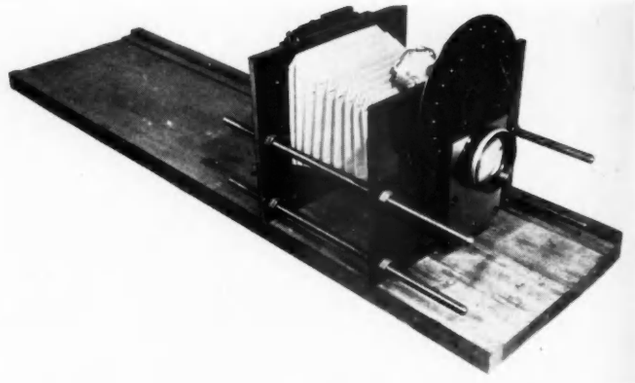


Fig. 11 Camera using Nipkov disc as scanning element in system illustrated in Fig. 8. The camera will record up to 200 successive frames at rates up to 50,000 per second.

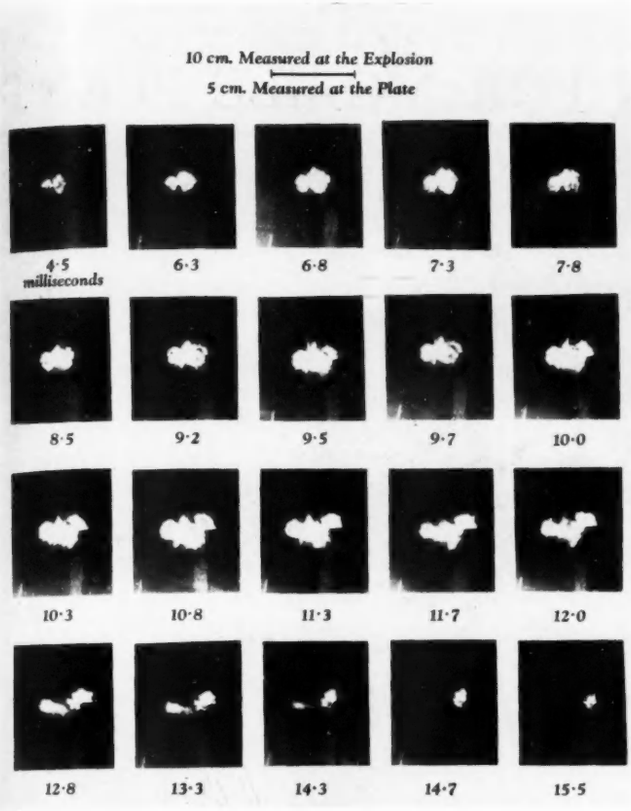


Fig. 12 Stages in the explosion of mercury fulminate, photographed with camera illustrated in Fig. 11. Twenty frames selected to show growth of luminous flame during explosion.

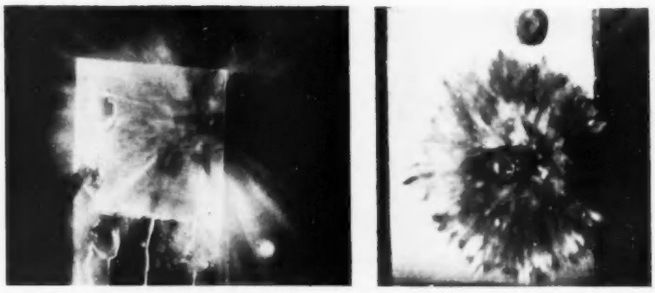


Fig. 13 (above) Impact of projectile on armour plate. Improved definition obtained in right-hand picture by use of Kerr cell shutter. *Crown Copyright photograph.*

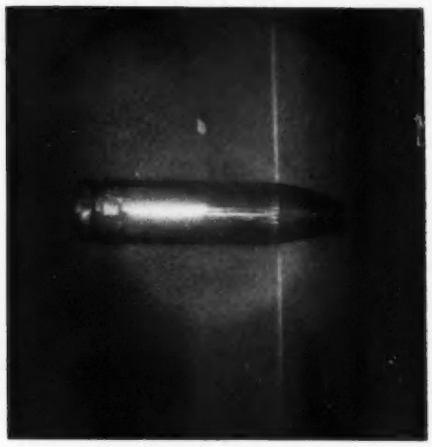


Fig. 14 (right) Projectile of 20 mm. calibre photographed in flight with an image converter shutter using electronic flash illumination. Exposure time one microsecond.

et J. Vivie. Dunod, Paris, 1956 (abstracts and legends in three languages, papers in authors' languages).

London, 1956. Published as " Proceedings of the Third International Congress on High Speed Photography," edited by R. B. Collins. Butterworths' Scientific Publications Limited, London, 1957.

In addition a comprehensive survey of current techniques, compiled by Dr. J. S. Courtney-Pratt, is published in Reports on Progress in Physics, vol. 20, page 379, The Physical Society, London, 1957.

Original papers on the subject in English are not confined to particular journals but appear not infrequently in the following two:—

United States: Journal of the Society of Motion Picture and Television Engineers, 40 West 40 Street, New York 18, New York, U.S.A.

England: Journal of Photographic Science. An organ of the Royal Photographic Society, 16 Princes Gate, London, S.W.7.

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[10] Courtney-Pratt, J. S., and Thackeray, D. P. C., " Actes du 2e Congrès International de Photographie et Cinématographie Ultra-Rapide," page 163. (Dunod, Paris, 1956.)

[11] Tuttle, F. E., *J.S.M.P.T.E.*, vol. 53, page 462, 1949. O'Brien, B., and Milne, G., *ibid.*, vol. 52, page 30; Sultanoff, M., " High Speed Photography " (S.M.P.T.E.), vol. 5, page 178, 1954; Young, A. F. B., and Legg, D., *J. Phot. Sci.*, vol. 3, page 10, 1955; Courtney-Pratt, J. S., *J. Phot. Sci.*, vol. 1, page 21, 1953; Courtney-Pratt, J. S., " Actes du 2e Congrès International de Photographie et Cinématographie Ultra-Rapide," page 152. (Dunod, Paris, 1956.)

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[15] Thackeray, D. P. C., " Proceedings of the Third International Congress on High Speed Photography," pages 21 and 42. (Butterworths, London, 1957.)

[16] Edgerton, Germeshausen and Greer, Incorporated, 160 Brookline-avenue, Boston 15, Massachusetts U.S.A.

[17] Mullard, Limited, Mullard House, Torrington-place, London, W.C.2.

[18] Saxe, R. F., and Chippendale, R. A., *Brit. J. App. Phys.*, vol. 6, page 336, 1955.

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[21] Hadland, J., and Company, " Scatterdells," Chipperfield, Hertfordshire ; Langham Photographic Services, 132 Stanley Park-road, Carshalton, Surrey; S.I.M.P.L., 1 Lambeth High-street, London, S.W.1.

RESEARCH ON AN INTERNATIONAL THEME

Scholarships Awarded by the European Coal and Steel Community

Closer European integration will obviously create a new situation which will require its own specialists. This fact has been recognised by the High Authority of the European Coal and Steel Community which has announced five research scholarships to the value of 500,000 francs (about £480) tenable for a period of eight months.

The first awards will be made at the end of June, 1958, with the object of encouraging research into the economic, legal and social problems of European integration. Candidates must be citizens of one of the Community's member countries or, and this lets in British students, of countries which have concluded agreements with the Community, or are members of the Council of Europe.

Research subjects may be chosen from two broad themes connected with the role of the E.C.S.C. in bringing about increased European co-operation. One theme is the contribution made by the experience of the E.C.S.C. to the working out and ratification of the treaties for the European Economic Community and Euratom, with particular reference to the part played by the institutions of E.C.S.C. in establishing and maintaining competition on the common market, the principle of free circulation of men and goods, the prohibitions of discriminations and subsidies and re-adaptation measures for labour. The other broad theme is the study of the results of the transitional period of E.C.S.C. (February, 1953, to February, 1958) in the perspective of the general common market. This will involve problems of integration in the coal and steel sectors and problems of general economic equilibrium, price formation, financial mechanisms, raw material problems and price alignments.

There is no doubt that whoever receives an award to work on these themes will have no lack of problems to get his teeth into.

Production

A STEELWORKS GOES IN FOR MOBILE PLANT

Scrapers, Shovels, Excavators at Steel Company of Wales

Maximum mobility and adaptability is the key to the economic use of plant. The speed with which raw materials can be delivered to any part of a works is vital to the maintenance of high production; and almost of equal importance is the rapid removal of waste products and debris away from the producing areas.

With these points in mind, the use to which traditionally civil engineering plant—scrapers, overloaders, mechanical shovels—is being put at the Abbey Works of the Steel Company of Wales is of great interest. The work formerly carried out by ore and coal gantries in the stockyards is being taken over by scrapers and stacking machines; mechanical shovels and heavy dumpers are used for loading and transporting raw materials; similar equipment is being used to demolish open-hearth furnaces and for clearing away debris (slag and bricks) during repairs to the furnaces. The plant is being streamlined into very mobile production units which can be switched rapidly from one part of the works to another. Not of least significance, is the improvements to the machines that are being demanded from the makers; these will reflect with advantage to the conventional users of such equipment.

In October, 1954, the company created a new department, the mobile and civil engineering plant department, to investigate the use of such equipment in their steelworks, to select appropriate machines and, subsequently, to manage their operation and maintenance. Initially, the department took over all the equipment in the company's possession and all hired plant being used in the works. The immediate advantage gained was that machines were then deployed on the basis of a works rather than a departmental priority, thus enabling a much higher degree of utilisation to be obtained and, incidentally, reducing the need for hired plant.

There are now about 160 machine-operating personnel in the department, a figure which is expected to rise to a little over 200 in about 18 months' time. There is also a workshop force of 120 which is likely to increase to 160; craftsmen make up about half of the shop force, the others being greasers, mates and labourers. Also under the care of the workshop is the fleet of 120 road vehicles belonging to the Steel Division of the company.

The work of the department falls into four parts. Firstly there is the finding and training of the operating personnel so that men will be skilful in handling specialised machines, yet be able to switch to others if the need arises; this has involved cutting across some traditional trade-union practices, but the company acknowledges the help and co-operation it has received from branch and area union officials in putting its plans into effect. Secondly there is the rationalising of the machines so that there is a high degree of parts standardisation; a particular issue here is the use of as few different engines as possible and, say, a specific move towards the maximum use of hydraulic controls and drives as standard equipment.

Thirdly, and following from the last item of machine rationalisation, there is the working out of a maintenance and replacements programme for each machine; the significance of this aspect of the work is increased by the fact that many of the machines which have so far been used were of American origin, for which spares were not easily obtained because of import restrictions. The fourth and final part of the department's work is the preparation of the day-to-day schedules for machine operation and the retrospective booking of hours worked the previous day against each machine. To assist in this work a simple wall chart has proved adequate with entries being made for each machine for yesterday, to-day and to-morrow. Out of the confidence that has grown among the

Euclid S.7 scraper operating in the main coal-stocking area. Note the condition of the tyres after 1,500 operating hours.

A Michigan 175A shovel handling iron ore in a blast-furnace stockyard. S.C.O.W. are using this type of plant because of its far greater mobility compared with fixed or semi-fixed equipment. In particular, rubber tyres permit higher speeds than crawler tracks and allow licensing for road use.

An Eimco 105 shovel clearing debris from a slag pocket of a 200 ton open-hearth furnace in the Abbey melting shop. The shovel has been given a higher digging action and more powerful throw to enable it to load into a Foden 15 ton dumper. It is also fitted with an A.F.V.-type door.

works staff that machines will be forthcoming when asked for has come the very desirable practice of only asking for machines when and for as long as they are actually required.

Characteristics affecting the selection of plant have included robustness—and in their original form few machines were adequate in this respect—and the fitting of heavy duty rubber tyres rather than crawler track. Relative maintenance costs were an issue in this respect but tyred vehicles have been adopted because they could be licensed to run on public roads, giving them the opportunity for maximum utilisation. Fluid transmissions have also been widely adopted because of low maintenance costs and the high manoeuvrability which they give, particularly that of being able to reverse quickly.

The work undertaken by these machines can be considered under two headings: the first is concerned with the handling of raw materials and general duties in and around the works; the second with the particular problem of preparing furnaces for re-bricking, including the removal of slag from the pockets.

For outside work the three most important types of machine—all rubber tyred—are the self-propelled scrapers, mechanical shovels and the cranes.

The choice of scrapers for the stockyards was based on the experience that purpose-made stockyards with fixed or semi-static installations quickly became obsolete and open stockyards served by crawler-mounted grabbing cranes and tracked bulldozers reached a stage in which they were both uneconomic and unpractical. In this setting the problem of coal handling and stocking became critical when, as a result of expansions in coke ovens plant, the daily consumption of coal rose to over 5,000 tons. It became necessary to hold a buffer stock of between 80,000 and 100,000 tons against holidays and dislocations in supplies, a problem complicated by the necessity of keeping separate stockpiles for the various grades required for blending.

It was eventually decided that rubber-tyred scrapers were the only machines that would meet all the requirements, in that they could both pick up and put down coal, make their own stockpiles, move rapidly over an extensive stockyard, carry loads without spilling (thus preventing contamination), compact the coal without crushing, thereby reducing the risk of spontaneous combustion, and increasing space utilisation. In addition, they were of relatively low capital cost, inexpensive in material and manpower to operate and could be readily diverted to other material handling work or housekeeping duties within the works. The particular machine selected for this work has been the Euclid S.7 7/10 cub. yd. scraper, shown in the first of the illustrations. After 16 months experience they have been found eminently well suited to handling coal (material of under $\frac{3}{8}$ in.) as well as other materials such as limestone and fine and rubble ores. For handling the coal, weighing only 45 lb. per cub. ft., it has been found practicable to fit 2 cub. yd. extension boards and to operate the scraper without the assistance of a pusher. For limestone or rubble ore, weighing 200 lb. per cub. ft., it has been found necessary to have the added assistance of a pusher to save wear and tear on the transmission, bowl controls and on slipping tyres.

As mechanical shovels Caterpillar 977's have been used at Abbey works since their introduction into this country; they were found to have all the requirements that the company desired except that of being mounted on rubber tyres—for which the minimum size was put at 1,500 × 20 if the hazards of steelworks operations were to be withstood. All the requirements—including an engine capacity in excess of 100 b.h.p.—were found with the Michigan 175A, which has proved adequate to the many tasks put on it without major alteration. In addition, it has proved to be an accomplished loader and pusher to use in conjunction with the Euclid scraper. These machines, there are now three at the works and one is illustrated on page 218, will also be used to get the added tonnage required from the stockyards for the new coke ovens; they will first lift and load direct to rail wagons from fringe stockpiles laid by the scrapers.

Two types of crane are now in use about the yard (apart from a few old rail-mounted steam cranes which are fast being replaced by Diesel-engined machines): the Neal 12 ton mobile crane with grab or magnet equipment, a 45 ft. jib and a safe-load device to prevent damage, should the magnet equipment get fixed firmly to material jammed in the scrap pile; the other is the new lorry-mounted 10/10 crane by Jones K. and L. Cranes. Both these machines work a 168 hour week in the steelworks and the power steering system and slewing clutches have had to be strengthened from those used on the original models. Also used are Crone and Taylor 70 ft. high stackers, often in conjunction with Walrus loaders; these have proved ideal for high piling low-density coke. Typical of the vehicles being bought is the Foden dump truck described last week on page 165.

More revolutionary, however, is the use of this type of plant within the melting shop. For a high steel output it is essential to get the old slag out of the furnace as quickly as possible and prepare for re-bricking. To dislodge speedily the slag accumulations, resort has been made to small explosive charges. There then remained the problem of demolishing the brickwork and removing the slag. The direct use of manpower is wasteful, for the work is arduous and exhausting even after the slag pockets have been given time to cool off.

Experiments with mechanical equipment were begun in the Abbey Works melting shop where the ground chargers are used to demolish the brickwork which is then dropped down the uptakes into the slag pockets. Reports from American steelworks had indicated that the best machine available for debris removal was the Eimco 105 shovel; one is illustrated at work, on page 218. This is a caterpillar-tracked machine of robust construction with a forward-mounted bucket which can be raised through an angle of more than 90 deg. to throw its load over its roof and into a vehicle behind. (Rubber tyres are not used here because of the heat.) Two 105's were, therefore, purchased immediately to tend to the eight 200 ton open-hearth furnaces at that time in the Abbey melting shop, and a third has since been purchased to cater for the four additional 230 ton furnaces which have been installed.

The Eimco as supplied did not prove entirely satisfactory for use at Abbey Works where slag is allowed to accumulate over two furnace campaigns, or about 26 weeks, as opposed to one campaign cycle operated in America. This results in the slag to be removed from the slag pockets being between 8ft. and 12 ft. in height. The Eimco is basically a tunnelling machine not designed to dig above about 5 ft.—the level of the digging stop. Operation of the bucket at a higher level causes it to run off its guide rails. For efficient use the digging stop has been raised; the main frame and transmission casing have been strengthened; and, as a safety measure, the side-opening doors have been replaced by one in the roof of the cab similar to that of an armoured fighting vehicle (this saves the driver from being trapped should the machine stall against the furnace wall).

Based on experience over the past three years, an operating method has now been worked out whereby two Eimco shovels are used, one in each of the two slag pockets of a furnace simultaneously, and a small bulldozer is employed to keep the area reasonably clear of fallen hot debris. A team of five machine operators is used to work in spells between the three machines to ensure continuity and reduce exhaustion as the whole operation is carried out in heavy dust, heat and steam. The debris material is loaded direct into heavy duty Foden dumpers which can be readily manoeuvred through the casting bay to the slag pockets as required.

At the Margam and Port Talbot melting shops the use of Eimco shovels is restricted due to the obstruction of heavy steel stanchions in front of the slag pockets. Moreover, the charger used is not suitable for the demolition of the furnace brickwork. To undertake both these tasks a Gradall excavator has been imported from the United States. This machine, which was designed for earth-moving and ditching, is a self-propelled tracked vehicle carrying a long telescopic arm which, besides being extended and retracted, can also be rotated and elevated, and a variety of tools can be fitted at the end of the arm. A number of improvements have been made to the machine to suit it to its present job and it is shown at work in two of the illustrations. It has been strengthened, particularly the tele-

A Gradall being used to demolish brickwork at stage level of a 100 ton open-hearth furnace at Port Talbot. The Gradall is then lowered to the casting bay where it is used in conjunction with two Caterpillar 977 shovels and Foden dumpers. Use of this equipment allows the stripping of an old furnace to be done at high speed and while the debris is still very hot.

Continuing Production

scopic arm; the controls have been re-arranged for safer operation; a set of tools have been made specifically for ripping out brickwork, debris and slag, and a quick-release tool holder fitted. An all-metal hosing has replaced the rubber hosing of the hydraulic control, at the boom end, as the rubber would not withstand the temperatures encountered.

In use, the Gradall first rips down the brickwork on the stage level and rakes it down the uptakes or on to the stage where small rubber-tyred shovels take it to disposal chutes. The machine is then transferred by crane down to the casting bay where the slag in the pockets has already been blasted; this debris is pulled out and loaded into Foden dumpers. As a loader the Gradall is too slow for the company's needs, and use is made of a Caterpillar 977 shovel to clear away while the Gradall is moved first from one pocket and then to the other.

To sum up, the company have found it most profitable to develop these items of civil engineering plant for specific use in and around steelworks. Capital costs are reduced—particularly in stock-yards where static or semi-static equipment has been done away with, at least for future works—and productivity has been raised, frequently with a smaller (though more skilled) labour force. Some problems still remain. One concerns the heavy-duty tyres. The question to be resolved here is when is the most economical time to have them re-lugged and when do new ones have to be bought?

AIR GAUGING APPLICATIONS

The air-gauging technique for checking dimensions to close limits, for many years a well-established practice in the automobile industry, has been gaining ground over a wider field during the past two or three years. The growing use of automatic assembly and transfer processes in industry, and the rapid development of high-speed aircraft and guided missiles, has led to a greater emphasis on precision mechanisms and servo systems. Manufacturers of high-precision parts who specify the clearance for mating parts, or the tolerance for size, in units of 0·000 01 in. are able to maintain these limits by using air gauges of the type made by Thomas Mercer Air Gauges Limited, Redbourn, Hertfordshire. The trend is also towards special-purpose air-gauging fixtures—sometimes of great complexity—designed to meet the customer's particular requirements and production set-ups.

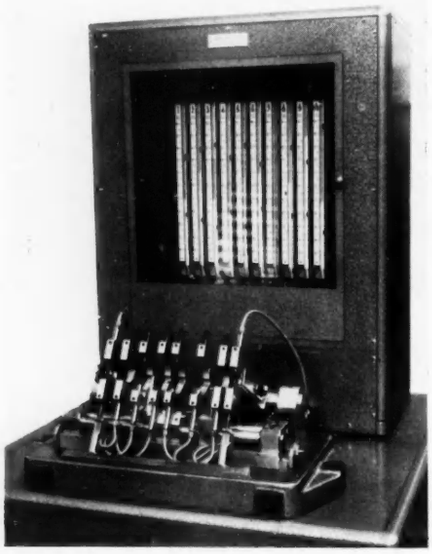


Fig. 1 On the new ten-column console unit, up to 10 dimensions can be checked simultaneously, the readings being displayed by means of liquid columns.

HIGH REGULATED PRESSURE

Before describing some air-gauging developments by Mercer, it may be desirable to summarise the principles of the technique. The parent company, Thomas Mercer Limited, are this year celebrating their centenary as manufacturers of marine chronometers and precision clocks—an activity which led naturally to their eminence in the making of precision dial measuring equipment; but it is only comparatively recently—in 1950—that they have entered the air-gauging field. Their system differs from that of most of the earlier established air-gauge makers in that they employ quite a high regulated air pressure—about 40 lb. per sq. in. at the control orifice—which has the advantage of automatically blowing away any swarf or oil deposits from the workpiece being measured.

In most Mercer air-gauging applications, apart from the actual gauging head, standard components are used. A typical gauge can be seen in the background of Fig. 3 below, which shows a machine-tool application. The system works as follows: air flows from the factory supply line, at 60 to 120 lb. per sq. in., enters the gauge through a cleaner unit and passes through a precision pressure regulator, the downstream side of which is held constant at 40 lb. per sq. in. From here the air passes to a control orifice, which can be adjusted to enable the gauging unit to be used with any type of gauging head, and thence to a sensitive Bourdon-tube pressure-measuring element and through a variable bleed to atmosphere (for adjusting the zero position of the pressure gauge) and to the measuring orifices in the gauging head, which is either plugged directly into the gauge or, if the latter requires to be remotely situated from the workpiece, connected by a flexible cable.

When the workpiece is located in the gauging head, the effective air-escape area from the measuring orifice is reduced by an amount depending on the dimension being measured. The flow obstruction causes the back-pressure to rise on the down-stream side of the control orifice (the up-stream pressure being held constant by the regulator) and to register on the indicator the deviation of the dimension from the desired figure. For each application, the gauge is calibrated by the user against a pair of suitable setting masters, sets of which are supplied with each gauging head; the dimensions of the masters correspond to the upper and lower limits of the part which is to be checked.

On most Mercer instruments, dial gauges are used with scales extending over bands of 0·002 in., 0·004 in., or 0·05 mm., and subdivisions in 0·000 1 in., 0·000 2 in., or 0·001 mm., respectively. To cater for increasing demands for readings down to 0·000 01 in., Mercer have recently introduced an ultra-high magnification dial indicator air gauge. Another recent development, for multiple gauging applications, is the multi-column console air-gauge unit using liquid columns for displaying the readings. The minimum display by this system is four columns (c.f. Fig. 1). The advantages claimed for the instrument are its open, clear scale, rapidity of response, and the ability to "hold" readings after the workpiece is removed from the fixture—a useful feature in machine-setting operations.

The gauging elements, of which Mercer produce a wide standard range in addition to custom-built special-purpose heads, fall into two main categories—those which use a direct air jet, the flow from which is modified by the presence of the part to be measured—which is not, however, in physical contact with the gauging element at the point of gauging; and those in which mechanical gauging contacts are used. (There is a third category in which a bore being measured is itself used as the air exit nozzle, but this is of restricted application.)

Mechanical-contact gauging elements, which can provide a wider measuring range than open jets and are also more suitable for use on rough or porous surfaces, include spring-loaded gap gauges, and Microjet plunger units in which a tungsten-carbide-tipped mechanical contact acts, through a plunger, to modify the pressure in the pneumatic system of the gauge. Microjets can be made compact and robust—the smallest unit being $\frac{5}{16}$ in. diameter and 1·25 in. long—and can be arranged to give an amplified signal. The latest addition to the range is a right-angle Microjet, illustrated in Fig. 2, for gauging bores. Because of their small dimensions, Microjet plunger units are used in the standard Mercer

Fig. 2 The right-angle Microjet plunger unit.

Fig. 3 Fine feed control of a grinding operation in Mercer's workshops is facilitated by a Microjet plunger unit. The air gauge seen in the background, into which the Microjet is flexibly connected, is one of the standard 4 in. instruments.

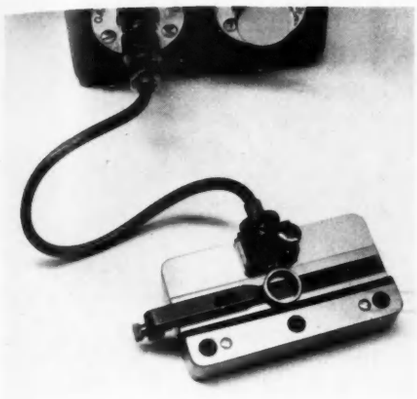


Fig. 4 Checking diameters of thin-walled bearings to 0·000 01 in.

comparator, in a wide range of multiple gauging units, and in the fine control of machine tools. Fig. 3 shows such an application in Mercer's own workshops where the in-feed to a grinder is controlled to within 0·000 04 in. by reference to a Microjet-operated air gauge.

SENSING BY DIRECT AIR JETS

The direct air-jet type of gauging elements include a variety of air mandrels for checking the diameter, straightness, location and other characteristics of bores; air ring gauges for outside diameters; and open-jet gap gauges recently developed for measuring outside diameters of thin-walled metal and glass tubing, etc., which must not be subjected to the spring pressure of a mechanical contact. There is a growing demand for very small measuring elements, particularly by the electrical and electronic industries, arising out of the trend towards "miniaturisation." Air probes are now available for checking hole diameters as small as 2 mm., provided that the bore is not too long; and for outside diameters, there is a miniature air ring gauge in sizes down to 2 mm. These very small gauges have a limited measuring range and their use is restricted to tolerance ranges not greater than 0·001 in. total. One special-purpose application was a small air probe to explore the whole 2 in. length of a rectangular bore, 0·125 in. by 0·06 in., in an electronic component. The successful production of this probe demanded extremely fine toolmaking to avoid spurious results due to unwanted restriction of the airflow in the very small feed-holes to the measuring jets.

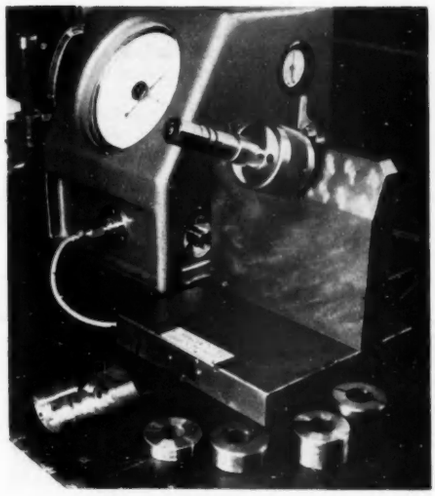
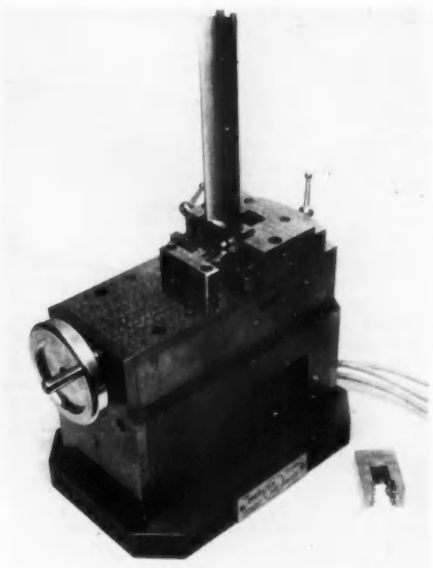
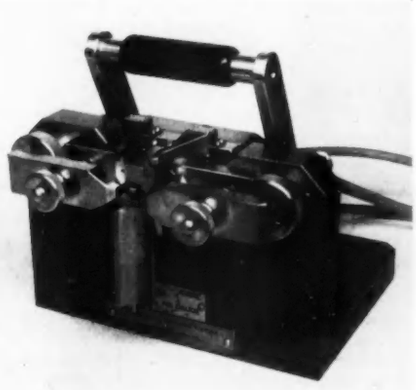


Fig. 5 Checking the position of cut-off lands within a hydraulic valve body.

The gauge shown in Fig. 4 was developed for checking the outside diameters of "outers" for high-precision bearings which had to be graded to five sizes within a total permissible variation of 0·000 2 in. from the basic size. Thus, the gauging element had to be capable of stable measurement of the order of 0·000 01 in. It was also required to be adjustable over a small range to suit sub-standard component sizes; and measurement had to be carried out with a minimum of handling, in order to keep down heat transfer. In this gauge, the bearing is placed between a slit jet and the lower guide rail, and against an adjustable end stop. No contact pressure is exerted. The whole gauge is tilted slightly so that, once the part is located, it is not necessary to hold it with the fingers.

In certain types of hydraulically operated servo-mechanism, the problem of determining the location of inaccessible cut-off lands is a difficult one which cannot be solved by any form of mechanical sensing. Fig. 5 shows a fixture for such a purpose, designed by Mercer in co-operation with Hydrosteer Limited, Luton (manufacturers of power-assisted steering). Here, the edges of the lands within a valve body are themselves used to obturate the air flow from a single air jet which is designed so that changes in linear displacement of the edge produce linear changes in back pressure in the air circuit;





Figs. 6 (above) and 7 (below) Fixtures for checking the root form of steam turbine blading. In the first-stage fixture (Fig. 6), the horizontal dimensions of the stepped faces are checked by direct jets. The vertical distances are measured in the second-stage fixture (Fig. 7), which uses Microjet probes actuated by fingers in contact with the workpiece.

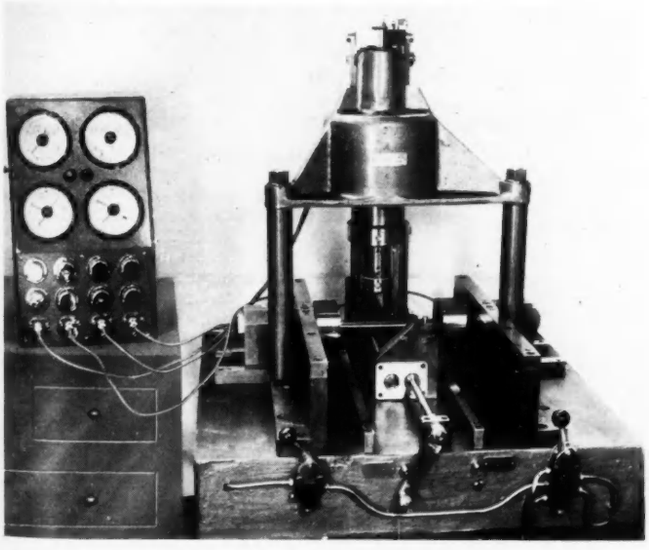


Fig. 8 Gauging large components: a heavy-duty fixture for rapid inspection of a rear-axle housing.

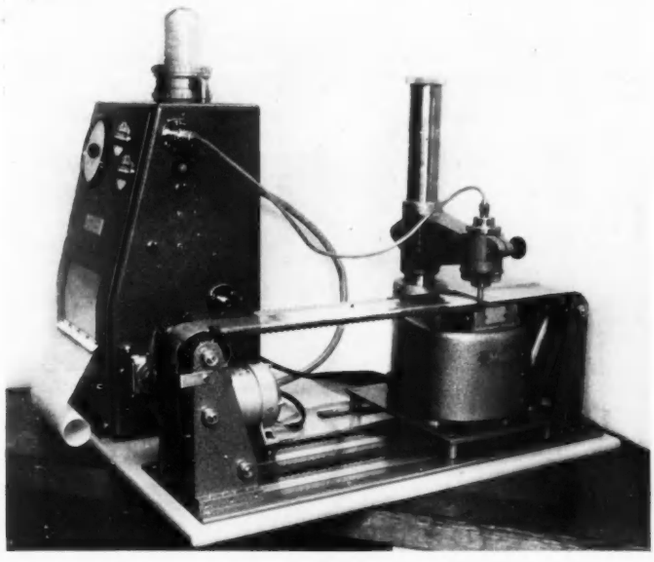


Fig. 9 Continuous thickness recording by air-gauging techniques of a thin plastics film.

Continuing Production

the component is placed on a mandrel and located manually against the turret backstops. The turret has a range of positions corresponding to the number of cut-off edges to be checked, the physical displacement of the stops bringing each edge in turn adjacent to the single measuring jet.

COMPLEX FIXTURES

Among the more complex fixtures developed to customers' requirements are two gauging devices for measuring quickly and accurately the intricate broached root forms of steam-turbine blades. For developing the pilot equipment, it was decided to break down the gauging operation into stages. The first stage was to measure the distances between the forks, the dimension from the datum face to one fork face and of five stepped faces from the datum face. Direct jets impinging on the work surface were selected as the simplest means of obtaining simultaneously all these readings. The jets were mounted in a block, seen in the right foreground of Fig. 6, which shows the fixture. The blade was located in a suitable clamping device so arranged that the measuring head could be passed completely through the blade form.

The second stage was to measure the relative vertical position of the fork face steps. Direct air jets were not practicable here, since the faces were quite narrow, so a gauging head was designed using four Microjet mechanical-contact air probes in conjunction with tungsten-carbide-surfaced fingers, the latter being mounted, on flexures, on a precision slide and passing over the blade form. Only the two upper contact fingers can be seen in Fig. 7. In this fixture, the blade is clamped to the fixture by a constant air pressure; the tracking of the gauging head over the root form is operated by the handle. The gauging head fixture is used in conjunction with a four-dial display unit. With slight modification, gauges of this type are now going into regular use in the machine shops of the turbine manufacturer, providing a much clearer picture of the variations than has hitherto been obtainable.

Shown in Fig. 8 is a heavy-duty rig designed for the rapid inspection of an automobile rear-axle housing. The component is placed on guide rails and is roughly located by hand. By operating the lever at the front of the machine, the workpiece is finally located by means of locating pins from accurately-positioned service holes. Three air-gauging heads are then offered to the component by pneumatic cylinders controlled by the levers at the left- and right-hand sides of the machine. The two horizontal gauging heads each check one diameter, and the vertical head measures two diameters. All the gauging heads are semi-floating to accommodate a small amount of misalignment; they can be rotated manually so that spot checks for ovality may be taken when required. Mechanical-contact type sensing elements are used to minimise errors due to varying surface finishes. All the movements of the machine are interlocked to prevent damage or injury to the operator. As may be seen in the illustration, the four-dial display unit is also equipped with coloured lamps for " out of limit " or " O.K." indication.

RAPID ROUTINE CHECKS

For rapid routine inspections on a production line, the use of coloured indicator lamps, in place of a dial gauge, to give easily-seen " go " and " no go " indications, is preferred by many firms, and in answer to this demand Mercer have introduced the electro-air gauge (Fig. 10). In this unit, pressure-sensitive Bourdon tubes, acting through a magnifying lever linkage, operate relays to provide the appropriate lamp indications. The dial display on the instrument is used only for calibration.

Another recent development for routine inspection is the recording air gauge, which

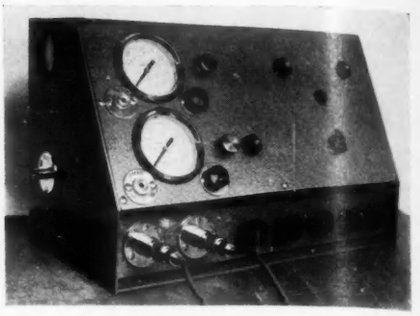


Fig. 10 The electro-air unit, for rapid routine inspections, gives " go " and " no go " indications on coloured lights.

provides a permanent record on a 4 in. wide chart, the total display range extending over 0·002 in. and graduated in 0·000 1 in. divisions. The recorder pen is operated through a linkage by the Bourdon tube element, and responds to dimensional changes of 0·000 02 in., with virtually complete repeatability, and without measurable hysteresis. The chart motor normally operates only when a part is being checked, the motor being switched off automatically when the workpiece is removed from the gauging head. There is, however, an over-riding switch which permits the motor to run continuously, so that the chart can be advanced and torn off for sampling purposes. An application of the chart recording equipment is illustrated in Fig. 9, which shows a standard high-precision air comparator, utilising the direct-jet system of measurement, in use as a continuous thickness gauge. The apparatus is, in fact, used by one of Britain's largest plastics manufacturers to measure and record the thickness of sample strips of a very thin plastics sheet material, providing the necessary monitoring for the main process.

Construction

REFINERY GASES USED IN HOMES

Shellhaven Supplies Romford

As a result of the shortage of good coking coals the gas boards have given increasing attention to the use of alternative fuels. Among these, oil and oil products naturally loom large. There are several processes now in operation in various parts of the country for forming towns' gas from various grades of distillate but the North Thames Gas Board's installation at Romford will be the first to use the gases that are produced during the refining of oil. In the main, these gases are a by-product and at present are used to heat the various processes at the refinery. They appear at the lower end of the hydrocarbon scale and, as produced, have a calorific value of about 1,500 B.Th.U. per cub. ft. This has to be reduced to 500 B.Th.U. before admission to the towns' mains.

The scheme, therefore, consists of three parts. First the cleaning plant at Shellhaven to remove corrosive elements including sulphur; second the pipe line to Romford; and third the transforming plant at Romford which will operate on the Onia-Gegi principle. At the present time the plant at Shellhaven is almost finished; the pipe line is laid except for the actual entry into the Romford site; and the transforming plant is expected to go into operation about May.

For economic reasons it was decided to transport the gases to Romford in their rich condition and at as high a pressure as possible.

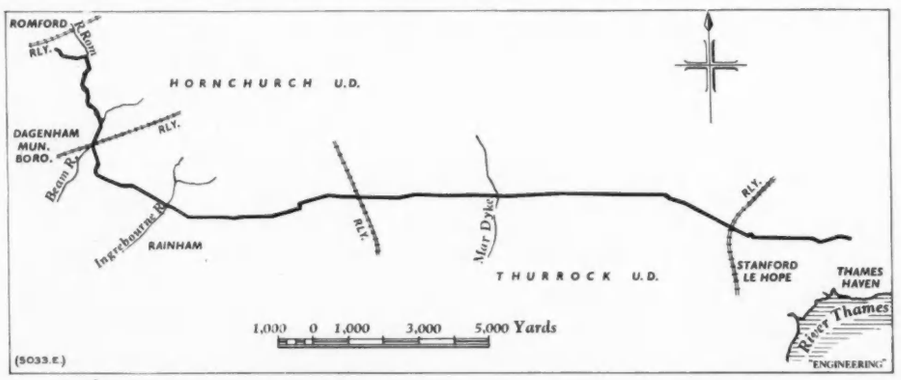


Fig. 1 The route followed from Shellhaven to Romford lies almost entirely in open country, much of which is marshy. Only one street was traversed.

This in turn indicated a steel pipe, as maximum pressures with a cast iron one would be about 30 lb. per sq. in. A steel pipe meant special protection from corrosion, not only internally but also externally, owing to the extremely marshy nature of the ground in that district. Cathodic protection made the plan possible, together with removal of the sulphur at the refinery.

The gases are produced at a pressure of about 160 lb. per sq. in., and after washing and drying enter the pipe at about 120 lb. per sq. in. The pipe is 24 in. in diameter and is 15½ miles long. The laying, completed in 4 months, was done by William Press and Son Limited, 22 Queen Anne's-gate, London, S.W.1. The route chosen avoided built-up areas as much as possible and lay mainly through farm and wild land. In fact only one road was traversed in the whole length. The outline map (Fig. 1) shows the general route taken. The pipes were sheathed by the makers, Stewarts and Lloyds, and were welded into strings on site. At intervals, wires were Thermite welded on to the pipe to form connections for the protective system.

The laying proceeded in stages. First the top soil was removed to a depth of 1 ft. and for a width of 40 ft. to form a working area with a firm surface (at that depth the soil was firm clay in most parts). This was carried out by a Caterpillar Traxcavater operated by one man throughout the whole period. A D.8 bulldozer helped to clear the route. The top soil was

piled on one side and afterwards was replaced so that the land was not injured. There then followed a Cleveland ditcher which cut the actual trench 40 in. wide and 7 ft. deep at a speed of 15 ft. per minute on the average. This machine weighed 29 tons and there were some places where it could not be used owing to the waterlogged nature of the soil. In these cases the work was done by a Ruston-Bucyrus machine but there was one spot which necessitated bucket and shovel work. Side-boom tractors, B.T.D.6 and T.D.18 types, handled the lengths of pipe and carried out the lowering into the trench. The flexibility of the pipe allowed a very quick method to be used. After the lengths had been welded into a string alongside the trench, the side-boom tractors lifted them in roller slings and then moved along parallel to the trench moving the pipe forward and lowering it at the same time. The rollers on the slings allowed them to follow the tractors as they moved. The slings are shown in Fig. 3.

Downhand electric welding was used enabling about 17 in. of weld to be run per minute. The welds were then checked by ultrasonic inspection. Where the sheath had been cleaned back and the pipe ends buffed for making the welds, the protection was restored by winding on layers of P.V.C. tape backed by a pressure adhesive. A rolling electrode, at a high potential and encircling the pipe, was used to detect any faults in the coating. Tests were carried out on the pipe in sections of about a mile for pressure leaks using air at 100 lb. per sq. in. When a leak was indicated it was traced by injecting a mixture of air and carbon tetra-chloride and using a B.T.H. halogen-gas detector probe. Before tests were carried out the pipe was cleared of any water or earth that had entered during the laying by forcing a "go-devil" plug through with compressed air. This procedure was also followed for the hydraulic testing of the completed pipe line at 400 lb. per sq. in. The quantity of water needed to maintain the pressure for 24 hours was a measure of the tightness of the line. A radioactive source in the go-devil allowed it to be located should it stick somewhere en route.

After the pipe had been laid the trench was back-filled, and the ground made good. This included rejoining field drains that had been cut during excavation, re-forming ditches where crossed by the pipe and replacing hedges, fences, etc. For the greater part of the way the pipe was laid directly on the bottom of the trench, but at railway crossings and at the crossing of the river Ingrebourne some concreting was required. The pipe comes above ground to cross the Mardyke as a self-supporting span of about 40 ft. For moving the plant across this and some other places a Bailey Bridge was used. The Ingrebourne valley afforded the greatest problem as the soil was virtually fluid.

At Romford, four units are being constructed to carry out the transformation. The plant, which is being built by Humphreys and Glasgow Limited, 22 Carlisle-place, London, S.W.1, is in the open and the controls are in a separate building. It is very compact and can be operated by three men per shift for an output of 36 million cub. ft. of gas per day. This is approximately 6 per cent. of the Board's total production. The cost of the plant will be about £1¼ million and of the pipe line about £½ million. The pipe line can also be regarded as a gas holder with an equivalent capacity of 5 million cub. ft. (at 275 lb. per sq. in., the designed maximum working pressure), which would have cost almost the same amount.

The initial contract with the Shell company is for 25 million therms per year for a period of ten years, which is equivalent to carbonising 250,000 tons of coal per year. At first, therefore, the line will carry about 4 million cub. ft. of gas a day but at its working pressure will be capable of 10 million cub. ft. per hour. This reserve capacity has been provided in view of possible future increases at Shellhaven and also of drawing similar supplies from Coryton through an extension of the pipe line. Moreover, there is an arrangement for taking in liquid methane at Canvey from imported supplies. From Romford the supply system links up with the rest of the Board's area and the new output should be sufficient to feed everything to the east of Romford and have some to spare to ease the load on Beckton. The capital cost of the new plant is about 1*d.* per therm as against 2·9*d.* for a carbonising plant. In addition, there is the saving in staff: as already mentioned, the new plant only needs three men per shift as against about a hundred for a conventional station.

Fig. 2 After cleaning the top soil from a 40 ft. wide strip, a ditcher cut the trench for the 24 in. steel pipe.

Fig. 3 Over many stretches the pipe was lowered into the trench by side-boom tractors using rolling slings which moved along guiding the pipe over the trench.

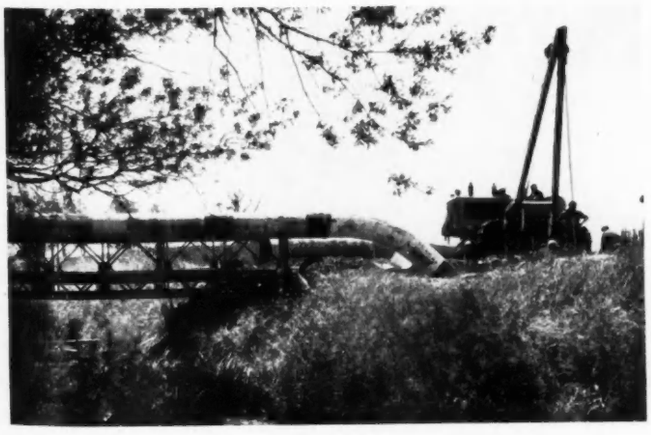


Fig. 4 The pipe passes under most ditches but spans the 40 ft. Mardyke as a self-supporting structure. The girder bridge is for the side-boom tractors and is clear of the pipe.

Fig. 5 (right) Leaks were located by a halogen detector, the pipe being filled with a mixture of air and carbon tetra-chloride at high pressure.

Engineering at Home

SOUNDS FOR TWO EARS

People often have a radio before they get hold of a television set. The one precedes the other. And it turns out that many homes have two radios: one on show, the other behind a cathode ray tube, giving out the television sound channel. If this is so, two loudspeakers are at hand and sounds can be knit together with them to give a listener a sense of sound in perspective: the familiar illusion brought about by a single loudspeaker, of an orchestra located at a point in space, falls away and the place of each instrument can be picked out. Something like the stereophonic sound of the modern cinema might be brought into the home.

Stereophonic recordings are available commercially. They are supplied on dual-track magnetic tapes and can be played through special equipment, for example, that manufactured by the General Electric Company Limited. Stereophonic sound equipment attempts to create for the listener, in his own environment, aural sensations similar to those experienced while listening to the original sounds. When listening to an orchestra normally, the two ears of a listener afford a discrimination that provides a sense of position and direction. In stereophonic reproduction this binaural effect is maintained by providing a two-channel system of recording and reproduction, starting with two microphones and culminating in two suitably spaced loudspeakers. The two channels are generally referred to as the right-hand and left-hand channels.

The B.B.C. put out some two-channel broadcasts last January. They found that you could get a stereophonic effect with a dual-track recording feeding two transmitters. Naturally listeners needed two receivers. On one day the television sound transmitter at Crystal Palace sent out the left-hand channel and the medium-wave Home Service transmitter at Brookmans Park sent out the right-hand one. To give stereophonic sound the two loudspeakers in a room had to be about 7 ft. apart and facing the listener; he needed to sit the same distance from each. Over 100 people did this and wrote to the B.B.C. saying how the broadcasts sounded. However, the B.B.C. say they do not mean to bring stereophony into normal broadcasting yet.

The stereophonic sound system creates its required impression by variations in the sound intensity from each of its two loudspeaker sources. When the intensities are equal, a listener situated in a position equidistant from each loudspeaker will decide that the sound appears to originate from a point midway between the two. However, when the listener displaces himself either to the left or to the right of the medial position, the balance is destroyed and the apparent source of sound moves in the direction of whichever loudspeaker is nearer to the listener. Both intensity and time differences contribute to the apparent movement and it has been found that both can be corrected by decreasing the sound from the nearer loudspeaker and increasing it from the further one: difference in time of arrival can be compensated by difference in intensity. In this way the apparent location of the sound can be restored to the medial position. Such correction has been found possible for time differences up to a maximum of approximately 5 milliseconds, after which the position of the apparent sound source becomes less definite. Using this method, G.E.C. claim to obtain good stereophonic reproduction along a line parallel to that joining the two loudspeakers and at almost any random position chosen by the listener behind that line.

About half the people who wrote to the B.B.C. found it hard to adjust their sets—the non-stereophonic items did not sound as though they came from midway between the loudspeakers. This lack of balance is brought about by the different times that the signals take to get to the two loudspeakers. Each signal goes along a different path and through a different receiver. Such random phasing of the loudspeakers holds out a fifty-fifty chance that it will be possible to balance the receivers. The makeshift radio system lacked the control of a self-contained system working straight from tape. However, some sense of the orchestra playing in the room was got by all the listeners. Ten per cent. of them said they could pick out the "positions" of the instruments.

In the G.E.C. equipment, directional sound sources generate a sound intensity that follows a particular pattern of distribution. For this purpose four "presence" units are employed, in addition to the two principal loudspeakers, to produce a line source of sound. By an asymmetric grading of the intensity of the sound reproduced from each unit, the specified pattern of sound distribution is achieved. The presence unit is a small loudspeaker that provides reinforcement in the middle top-frequency range, and it governs the distribution pattern in this range. At lower frequencies the required pattern becomes more nearly hemispherical and no special orientation of the loudspeaker system is necessary. The equipment uses twin amplifiers and "presence" controls enable the user to compensate for the acoustic properties of his particular room and to adjust the reproduction to his own individual subjective requirements.

TOOLS AND MATERIALS FOR D.I.Y.

Between February 19 and March 1, the Empress Hall, Earls Court, will be occupied by the *Practical Householder* exhibition, which is designed for people who are interested in what is becoming known as the D.I.Y. movement (do it yourself). Tools, materials and accessories will be displayed and a feature will be the large number of demonstrations. It is expected that about 90 firms will take part. Some of the products that will be exhibited are mentioned briefly below.

The present exhibition comes five months after the Handicrafts and "Do It Yourself" Exhibition held at Earls Court last September, and many items will be being displayed for at least the second time. This is to be expected in an industry that has a strong conservative element and emphasises that the demonstrations and inquiry services offered by the stands play a very important part in any exhibition of this type. The products mentioned below have nearly all been exhibited before but are enumerated in order to give some idea of the sort of equipment being shown.

Gyproc Products Limited, Gravesend, Kent, are exhibiting Gyproc Cove—a fire-protective gypsum core encased in ivory-coloured millboard. The product is available in standard lengths of 10, 12, and 14 ft., and is a decorative fitting that can be attached in the wall and ceiling angle. In position it presents to view a concave curve of 3 in. radius. It is useful for concealing cracks between ceiling and wall caused by structural movement. The product has a 5 in. arc with $\frac{1}{4}$ in. wall and ceiling members and weighs about 1 lb. per linear ft. Two methods of installation are available: adhesive and nailing or screwing. The surface is not suitable for plastering but most other forms of decoration are possible.

Wolf Electric Tools Limited, London, W.5, will be exhibiting their Quartermaster range of home power equipment with attachments and accessories. The latest attachment is a jig saw for making straight or complicated cuts in a variety of materials and for bevel cutting up to 45 deg. Continuous demonstrations will be given daily of the constructions of toys, models, and small articles of furniture.

John M. Perkins and Smith Limited, Braunston, will be exhibiting their Blue Flash masonry drills for the first time. The company say that the drills have a tungsten carbide tip electronically brazed with copper so that they can be used in portable electric drills running at speeds in excess of 3,000 r.p.m., without the brazing being affected by the heat. The drills are suitable for brick, cement, stone or breeze. A special Green Grit wheel is available for sharpening tungsten-carbide-tipped drills at home.

An electric paint stripper will be exhibited by the Skarsten Manufacturing Company Limited, Welwyn Garden City, Hertfordshire. The tool operates from the mains supply and contains a heating element and a scraper. It is held in one hand and a distance rod enables the heating element to be raised or lowered in relation to the surface being stripped in accordance with the number of coatings to be removed.

Walter Carson and Sons Limited, Battersea, London, S.W.11, will feature colour displays and their aids to colour selection. Members of the company's staff will give advice and answer questions on painting problems. The company issue a number of technical memoranda that deal with their products and give information on such problems as blistering, blooming, cissing, and the bleeding of creosote, tar or bituminous paints.

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